BIOGRAPHICAL MEMOIRS OF FELLOWS OF THE INDIAN NATIONAL SCIENCE ACADEMY

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PREFACE

I am happy to place before you the Volume XI of the Biographical Memoirs of the Fellows of the Academy. The present volume contains the memoirs of sixteen eminent Fellows from various disciplines who left their mark in international scientific scenerio. The volume is a glowing tribute to them by their fellow workers.

Professors Priyadaranjan Ray, Phanindra Chandra Dutta, Ramanlal Chhaganlal Shah and Satyandra Nath Chakravarti devoted their life working in different fields of chemistry. Professor Ray, a Foundation Fellow of the Academy, was an inorganic chemist of repute and an acknowledged authority on complexes, valency and microchemistry. Professor Dutta worked for over two decades on synthesis of the complex terpenoid natural products and synthesis of polycyclic compounds. Professor Shah was a well known organic chemist in the fields of synthetic drugs and insecticides. Professor Chakravarti was a pioneer in forensic chemistry and chemical investigation of medicinal plants.

Professor Rango Krishna Asundi was a pioneer in the field of molecular spectroscopy. Working with carbon monoxide, he discovered an electronic band system which has since been named after him. Arthur Lennox Coulson's contribution to geological investigations including mapping of Bundi and Sirohi regions of Rajasthan, the then North-West Frontier Province and of Kashmir mainly concerned engineering geology and ground water survey. Professor Satya Swaroop, a demographer devoted his activities mainly to epidemiology and population statistics.

Dr A C Ukil, a past President of the Academy (1955–56), worked on various aspects of tuberculosis infection and will be long remembered for his contributions in promoting research and education in medical sciences. Dr J A Sinton, a Foundation Fellow of the Academy, contributed much to malaria research including parasitology, treatment and control.

Dr Nibaran Chandra Chatterjee and Dr Hem Singh Pruthi devoted their career to entomological research. Dr Chatterjee worked on the spike disease of sandal wood tree and on the control of sal wood borer. Dr Pruthi, a Foundation Fellow, studied pests of cotton, oilseeds crops, wheat and fruit trees. Dr Pruthi's major contributions were on the control of locust infestation in India. The credit for pioneering sugarcane breeding goes to Sir Tiruvadi Sambasiva Venkataraman. The varieties of sugarcane developed by him revolutionized the sugar industry not only in India but also in the sugar producing countries abroad.

Professor H N Ray worked on parasitic protozoa and identified many new species and genera. His discovery of malarial parasites in the liver of the Himalayan giant flying squirrels won him international repute.

Professor Ponani Narayan Ganapati was a pioneer in the field of marine biology, marine pollution, benthic ecology and in the study of parasitic protozoa in marine worms and fishes. Dr Ajudhya Nath Khosla, a past President of INSA (1961–62), was an engineer of international repute who worked on problems of lavelling rivers, flow of water in porous sub-soil, concrete, RCC and precast units etc. He was associated with major power projects of our country including Bhakra and Sutlej Dams.

I record my sincere thanks to the contributors to this volume. I am also thankful to the Editors Professors G S Venkataraman and A N Mitra, and to Dr A K Moitra for this publication.

C N R Rao

President

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PRIYADARANJAN RÂY

(1888–1982)

Foundation Fellow

"THE life that is well spent is a long life", wrote Leonardo da Vinci. This beautifully summarizes the life of PRIYADARANJAN RÂY who lived upto ninety four years, combining in himself the erudition of a scholar, creativity of a scientist, wisdom of a philosopher and saintliness of an ascetic. His death has left a void, hard to fill.

Professor Rây symbolized the best of Indian tradition and philosophy, buttressed with scientific reasoning, analytical approach and a missionary zeal in the pursuit of knowledge. He was an example of modesty, which is expressively recommended to the scientific worker in the 'Essay on Man' by Alexander Pope : Modesty thy Guide.

His researches cover various aspects of coordination chemistry, magnetochemistry and microchemistry and he is aptly considered a doyen of inorganic chemists in India. Neither glamour nor publicity had any attraction to him, even though they followed at his heels.

Successive generation of chemists were trained by him, many of whom have earned distinction in their lives. Neither age nor his virtual blindness during the last fifteen years deterred him from creative activities. As 'Paradise Lost' flowed through the blindness of Milton, Rây's moving finger moved on during these years through science, philosophy, religion, culture and socio-economic problems. His writings are 'Paradise Regained' for us.

To him, science and spirituality were not contradictory, but complementary and he believed in their harmonious orchestration. Priyadaranjan was neither a dogmatist nor an agnostic, but like Sri Aurobindo, realised the limitations of physical science. Science, to him, is not the ultimate, but a means to pursue what is beyond. It never corrupts the concept of God, but only confirms the divine superiority and man's limitations. He believed that there was nothing in science that could in any way disturb religion which has its foundation not on irrational doctrines and unscientific creeds but on the deepest experiences of the soul. Knowledge for its own sake and service to mankind were his motto and truthfulness and righteousness were his principal code of conduct. He was a great believer in the rationalizing influence of science on the human mind and thinking. Few men have been so catholic as Rây. He always used to extend his sympathies and charities to all who approached him to help the needy to the best of his power.

EARLY LIFE AND EDUCATION

Priyadaranjan was born on Monday, January 16, 1888 in a well-known zamindar (landlord) family in the village Noapara in the district of Chittagong (now Bangla Desh). This village, situated on the bank of the river Karnafuli, was the home of the ancestors of the Ray family for over 200 years. Anand Rây, an ancestor of this Ray family, migrated during the Maharashtrian uprising (1663-1680) from the village Tribeni in the district of Hooghly (of the present West Bengal) to the state of Tripura. His eldest son Vishnuprasad was an intelligent and accomplished person who secured a high rank in the court of Nawab Murshidkuli Khan of Bengal. In recognition of his meritorious services, he obtained from the Nawab several villages of Chittagong district to establish the zamindari for the Rây family. His eldest son settled at Noapara village, which thus became the ancestral home of Priyadaranjan.

This zamindar family of Noapara was well-known for their benevolence, righteousness and service for the promotion of education and learning. The famous poet of Bengal, Nabin Chandra Sen, belonged to this family. There were quite a few other illustrious personalities of Bengal who had their origin in this Rây family. They were Akhil Chandra Ray, the renowned advocate of Calcutta High Court, Rajani Ranjan Sen, well-known literateur and Birendra Binode Ray and Bibhuti Bhushan Sen, the reputed educationists. Priyadaranjan's father Kali Kumar Rây, was a Sub-Deputy Collector of Rangamati in Chittagong, and his mother Shymasundari Devi was an accomplished lady of enlightened views, to whom Priyadaranjan was deeply attached. He was the third of the four sons and three daughters of his parents.

Priyadaranjan had his early education in the village *pathsala,* where he came under the tutelage of Rashmohan Sen, a teacher of repute and profound integrity. Having finished his primary education, he joined the Chittagong Collegiate school in 1899. In the year 1902, when he was a student of class IX, his father expired. In spite of this mishap, Priyadaranjan passed the entrance examination from Chittagong Collegiate School in 1904 in the first division securing the 'Rai Bahadur Golakchandra Scholarship'. He then joined the Chittagong Government College and passed the FA (First Arts) examination in 1906, securing a merit scholarship and a certificate for originality in Bengali composition, a talent which found prolific expession in his later scientific and philosophical writings.

At the Presidency College, Calcutta

In July 1906, Priyadaranjan came to Calcutta for higher education and joined the first year BA class in Presidency College. He became a boarder of the Eden Hindu Hostel, where Dr Rajendra Prasad the first President of India, was a fellow boarder and monitor. At the Presidency college, he came in contact with renowned teachers like Principal H M Percival, Acharya Jagadish Chandra Bose and Acharya Prafulla Chandra Rây. In 1908, he passed the BA Examination from Presidency

College with Honours in both Chemistry and Physics. In addition to the science subjects, he studied English, Bengali and Sanskrit languages in his BA course. Later he attained proficiency in German language also. Acharya Prafulla Chandra Ray's inspiration persuaded him to take chemistry for his MA examination, which he passed in 1911 securing the first class first in the order of merit, and thus, secured the University Gold Medal and the Motilal Mullick Gold Medal. In his MA class he had Hemendra Kumar Sen, Biman Bihari De and Ramesh Chandra Ray as his fellow students. All of them subsequently attained distinction as renowned chemists and teachers.

EARLY CAREER AND ACCIDENT

In 1911, Priyadaranjan started research work in inorganic chemistry under Sir P C Rây at the Presidency College. In collaboration with his colleague H K Sen, he published his first paper entitled "The action of hydrazine and hydroxylamine on ferricyanides and a new method for the estimation of hydrazines and ferricyanides" [Die Einwirkung von Hydrazin and Hydroxylamins auf Ferricyanide und neuer Methoden zur Bestimmung von Hydrazin and Ferricyaniden]. which was published in Germany in *Z. anorg. Chem. 76, 380, (1912)*. On August 12, 1912, he met with a severe accident which culminated in total loss of his left eye and serious damage to his right eye and other parts of his body. Professor N R Dhar gives the following description of the accident : "We contemplated a joint research project in 1912 on complex formation between cuprous thiocyanate and potassium thiocyanate. I tackled the problem from electric conductivity measurement and he took up the thermal method by fusing potassium thiocyanate to which copper thiocyanate was added. Unfortunately the beaker containing potassium thiocyanate which was being heated on a bath of strong sulphuric acid, broke down and there was a terrible explosion, which ruined one of the eyes of Priyadaranjan Rây". At the instance of Sir P C Rây, he was immediately removed to the Calcutta Medical College Hospital, where he remained a cabin patient for about a couple of months. He was practically incapacitated thereafter and had to stay away from Calcutta for about two years to recuperate his lost strength.

TEACHING CAREER AT THE UNIVERSITY COLLEGE OF SCIENCE, CALCUTTA

He returned to Calcutta in 1914 and joined the City College as a Professor of Chemistry. At this time, Sir Asutosh Mookerjee, the Vice-Chancellor of the Calcutta University, was looking for competent young teachers and research workers to join the newly established University College of Science, to help and assist Acharya Prafulla Chandra Rây, then Sir Tarak Nath Palit Professor and Head of the Department of Chemistry, who would be able to develop the university to an advance centre of scientific research and teaching in the country. Priyadaranjan was one of those who was picked up by Sir Asutosh for this purpose and in the year 1919 he joined the University College of Science as Assistant Palit Professor of Chemistry.

Here he devoted himself to teaching and research and was given the charge of organizing and developing the inorganic chemistry section of the Department of Chemistry. It was by his devotion and perseverence that he ultimately succeeded, inspite of many odds, in establishing a renowned school of modern inorganic chemistry in the University College of Science. Here he devoted the best part of his research career for nearly four decades till his retirement, in 1952.

In the words of his *guru*, Sir P C Rây : "Priyadaranjan Rây is regarded as an acknowledged authority on complexes and valency and also on microchemistry and it is my practice to submit my own papers to his criticism and judgement before they are contributed to the chemical societies. My presidential addresses at the annual meetings of the Indian Chemical Society of 1926 and 1929 are based mainly upon his ideas and suggestions. A more silent and unobtrusive worker is seldom to be met with." Priyadaranjan had always been a silent worker throughout his life, who never had any lust for decoration, such as a doctorate degree, nor any inclination for foreign travels. It was through much effort that Sir P C Rây could persuade him to visit Europe on a Ghosh Travelling Fellowship of the Calcutta University. He went abroad as a Visiting Professor to work in the laboratory of Professor Fritz Ephraim in Berne, Switzerland in 1929. Here he had to undergo optical microsurgery to improve the partial vision of his right eye. In 1930, he became associated with the Austrian microchemist, Professor Frederic Emich in Graz. Finally, he made an extensive tour of Europe, visiting many renowned chemical research centres in Germany, France, Czechoslovakia, Hungary, Holland and England and returned to India by the end of 1930. He never left India again in spite of numerous invitations from abroad to attend international seminars and conferences.

He resumed his teaching work as a lecturer in inorganic chemistry in the university. In 1937, he was appointed as Khaira Professor of Chemistry and in 1946 as Palit Professor and Head of the Department of Chemistry.

He was spell-binder as a teacher. Students of inorganic chemistry from all parts of India came to learn at his feet. He taught and guided them with meticulous care. He was passionately devoted to teaching, both in the lecture hall and in the laboratory. What was appreciated most was his ability to explain difficult subjects with great lucidity. He never went beyond what was relevant, having been always precise and to the point. He stood up to the ideals of a true teacher—one who is interested not in the extent of his teaching but in assessing how much his students have understood and learnt of all that has been taught. His detailed guidance in practical work was of lasting value and thus left a deep impression in the minds of his students. Scores of them got doctorate degrees and went abroad to seek fresh laurels. He wrote hundreds of illuminating scientific papers, while world recognition waited at his door.

AT THE INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE, JADAVPUR

While still in service at the Calcutta University, Professor Priyadaranjan Rây kept intimate contact with the Indian Association for the Cultivation of Science as its Honorary Secretary and subsequently as its Honorary President. It is the oldest research institution in India, having been founded by Dr Mahendra Lal Sircar as early as 1876 with the intention to "combine the character, scope and objects of the Royal Institution of London and of the British Association for the Advancement of Science". After retirement from the Calcutta University, he formally joined the Association as an Honorary Professor with Professor Meghnad Saha as its Director. When Professor Saha died on 16 February 1956, Professor Ray took over charge of the Association as its Director. He was mostly responsible for organizing the chemical research wing, where he activated a new school of modern inorganic chemistry. During this period he donated Rs 30,000/– to the M N Saha memorial fund of the Association out of his remuneration. After he finally retired from the IACS in 1958, he ceased to be actively associated with any research laboratory. Instead, he continued to function as a Supervisor-in-Charge of the History of Science unit of the Indian National Science Academy at the Asiatic Society, Calcutta for several years, guiding the investigations of a team of young workers on the progress of science in ancient and medieval India.

SCIENTIFIC CONTRIBUTIONS

Modern inorganic chemistry is to a large extent concerned with various aspects of chemical species all of which belong to the class of coordination complexes in a broad sense. Professor Rây's contributions cover such diverse aspects of coordination complexes like studies on new types of ligands, stabilization of unusual oxidation states of metals through coordination, structure and stability of complexes etc., and applications of complex-formation and complex-formers in the detection and estimation of metals in macro and micro quantities. An impartial assessment of the quality of his research work is possible only in the context of similar contemporary work in India and abroad, and of the methods and techniques then available for elucidation of structure, bonding, etc. Some of his suggestions regarding structures of some of the compounds investigated by him have been modified in view of data obtained by means of more sophisticated techniques, but these are merely the usual process of evolution in science. But many of his findings and suggestions have withstood critical scrutinity, and are still referred to widely in current lieterature. The honour and esteem in which Professor Rây is held is revealed in an article 'Die neuere Entwicklung der anorganischen Chemie' [Silver Jubilee Souvenir, National Academy of Sciences (India), p. 120] written by Professor Wilhelm Klemm, Director, Anorganisch-chemisches Institut, University of Munster, West Germany. Professor Klamm wrote as follows :

> "In giving an account of the modern developments in the field of inorganic chemistry, I cannot conclude without referring to the contributions of the Indian workers in this field. Mention of names like Raman, Krishnan and P Rây will, in my opinion, suffice for the purpose".

The first publication of Professor Rây appeared in the year 1912, on the reaction of hydrazine and hydroxylamine with ferricyanide and its application as a new method of estimating hydrazine. This was followed by studies (1920) with Professor P B Sarkar, on the complexes of the type M $(N_2H_4)_2$ $(SCN)_2$ formed by bivalent metals, which were later utilised by Sarkar and coworkers for the gravimetric estimation of nickel, cobalt and cadmium. The considerable amount of work done by Professor Rây and his associates on organic reagents has led to the introduction of substances like rubeanic acid and its derivatives, quinaldinic acid, dimercaptothiobiazone (now known as Bismuthiol-I), biguanide, cystin and several substances (amidoximes, hydroxamic acid etc.) as useful analytical reagents for volumetric, gravimetric and spectrophotometric determination of metals.

It may be mentioned that rubeanic acid is still the most sensitive reagent known for the identification Cu^{2+} ion. In faintly ammonical medium it can detect one part of the metal ion in about thirty million parts of the solution (1926). Use of this and of several other complex forming reagents for the spectrophotometric estimations of several metals have been described (1956–60). Precipitation methods involving internal generation of the reagent (homogeneous precipitation) are recognized now a days as much more useful than the conventional methods of adding the reagent from an external source. This principle was applied as early as 1928 by Professor Ray in the quantitative separation of the less basic trivalent metals of the ammonia group of the usual analytical scheme from the more basic bivalent metals like Zn, Mn, Ni and Co, using urotropin (hexamethylenetetramine) for generating ammonia in situ. Mention must also be made of a novel volumetric determination of HgO in mercury compounds, in which HgO is reacted with sodium thiosulphate and the liberated alkali is then titrated with standard acid.

Professor Ray's contributions on various aspects of coordination complexes have been no less significant. Some of the major contributions will be mentioned briefly. The isomerism of thiosulphuric acid was clearly established for the first time by him by isolating two isomeric forms of the complex acid $H_4[Co(CN)_5S_2O_3]$ which exhibit different modes of decomposition corresponding to that expected for the two linkage isomers derived from the isomeric forms of thiosulphuric acid. The complex thiosulphatopentacyanocobaltate (III) ion is a novel one and it forms stable salts; the potassium salt was obtained by treating the complex salt $[Co\ (NH_3)_5S_2O_3]$ Cl, also prepared by Professor Ray, with excess of potassium cyanide. Several other thiosulphate and sulphito-ammine complexes of cobalt (III) have been prepared and studied by Ray and coworkers.

In 1925 Professor D M Bose, Ghosh Professor of Physics, Calcutta University became interested in the magnetic behaviour of some compounds containing paramagnetic ions of the iron group. Many of these compounds had six molecular groups like water or ammonia and belonged to Werner's classification as coordination compounds. Some ammoniated compounds were found to be diamagnetic, while the hydrated compounds were paramagnetic. To account for such anomalous behaviour, Bose proposed a rule, which subsequently became known as Bose-Welo rule. Bose became interested in the experimental study of Werner's classic coordination compounds, when he came to know that Professor Ray, the then lecturer in the chemistry department was preparing a novel group of coordination compounds. Thus Professor Ray was attracted to the domain of magnetochemistry and became a pioneer in the field in India. His first paper in magnetochemistry is entitled : "Magnetic properties of complex compounds and their electronic constitution."

The constitution of the two isomeric forms of the salts of the complex cation $[Co\ (NH_3)_5NO]^2$ was established by measurement of magnetic moment (1943). The black form being paramagnetic, was considered as the usual cobalt (II) complex containing coordinated NO molecule, while the diamagnetic red variety was thought as a complex of cobalt (III) containing NO^-ion. These assignments clearly followed from the well known principles of magnetic moment and its relation to valency in complex compounds. The complexing ability of biuret, $H_2N.CO.NH.CoNH_2$ is well known, the Cu^{2+}—biuret reaction being a classical example. Replacement of the O in the -CO- groups in the biuret by NH and/or S might be expected to lead to more pronounced complexing ability. In fact, Emisch as well as Friedrich, described a few compounds of copper, nickel and cobalt with biguanide in the latter half of the nineteenth century even before Werner's classical work on coordination complexes. Ray and his coworkers (1937–60) have systematically investigated the ligational properties of biguanide, $H_2N.C\ (:NH).NH.C'\ (:NH) — NH_2$ and its derivatives dicyandiamidine, $H_2N.C.\ (:HN).NH.CS.NH_2$, and dithiobiuret, $H_2N.CS.NH.CS.NH_2$. The metal complexes of a large number of Schiff's bases have also been investigated.

The complexes of biguanide and its derivatives are particularly interesting because stable chelate complexes of biguanides have been obtained with a number of common bi-and tri-valent metal ions. The square-planar complexes of the substituted (unsymmetrical) biguanides with copper (II) have been obtained in two different coloured modifications whose infrared spectra have indicated the possibility of cis-trans isomerism. Several nickel (II)-biguanides have also been obtained in different coloured modifications. A series of tris-biguanide and a few bis-biguanide complexes of Cr(III) and Co(III) have been prepared, as also some dicyanobisbiguanide complexes of cobalt (III).

The mode of linkage of the ligand in metal-biguanide complexes was inferred by chemical methods. Complexes of substituted biguanides having an acid group ($—SO_3H$) in the substituent, present another interesting class of inner-metallic complexes. Ethylenedibiguanide, Etdi (bigH), is a quadridentate ligand which has been useful (1944) to stabilize the tripositive state of silver in the form of orange-red complex $[Ag\ \{Etdi\ (bigH)\}]\ X_3$. This is the most stable compound of silver (III) known so far. Its diamagnetism confirmed the existence of silver (III) in a square-planar structure in the complex. Complexes of Mn(III), Mn(IV), V(IV), Re(V) etc. with biguanides have also been described. The chemistry of the metal biguanide complexes opened up a new chapter in the field of coordination compounds and an exhaustive review on the subject was published by Professor Ray in the Chemical

Reviews in 1961, on which Professor M T Beck (Hungary) commented : "I am extremely interested in your work on the chemistry of biguanide complexes. So I was excited to read your impressive review which appears to be a real gold-mine."

Mention need also be made in this connection of the preparation and characterization of several complexes of silver (II) formed with pyridine mono-, di-, and tri-carboxylic acids, by Ray and coworkers. Professor Ray's monograph on 'Chemistry of bi- and tri-positive silver' published by the National Institute of Sciences of India (now the Indian National Science Academy) in 1960, is an excellent and uptodate report on the higher oxidation states of silver. Other important contributions in the field of coordination complexes include studies (1946) on a nickel (IV) complex of periodic acid, $MNiIO_6$ (M = alkali metal), complexes of rhenium (IV) with organic acids, some heteropolyacids of niobium (V) and tantalum (V) lead (IV) titanium (IV) etc. and on the constitution of polymolybdates (1941–43).

Reference has already been made to the use of magnetic moments of some of the complexes, studied by Professor Ray for elucidation of the structures of the complexes and the valency of the central metals. From a consideration of the magnetic properties of many compounds of transition metals he suggested (1928) classification of the coordination complexes into two different types, distinguished as penetration and associated complexes. They are now represented as inner orbital and outer orbital complexes respectively, indicating thereby whether orbitals of the penultimate valence shell or the valence shell of the metal are utilized in bond formation with the ligands. He is one of the earliest workers on the systematic application of magnetic properties in the studies on problems of valency in coordination complexes. From a systematic investigation of the magnetic moments of a large number of copper (II) complexes, Professor Ray concluded (1948) that all these can be classified into two groups based on their moment values (1.7 and 2 B.M.). On the basis of the valence bond theory developed by Pauling, these were classified as representing complexes of the inner orbital, dsp^2 and outer orbital, sp^2d, types respectively. In terms of modern views of the ligand field theory, however, these probably represent square-planar and distorted (Jahn-Teller) octahedral complexes respectively.

As early as 1940, making use of radioactive iodide, Rây demonstrated in collaboration with Professor S D Chatterjee, the equivalence of all the bonds in complexes like HgI_4^{2-} and BiI_4^-, showing that Werner's 'primary' and 'auxiliary' valencies are indistinguishable in the complex. They further succeeded in isolating the radioactive isotope of cobalt of long life by a chemical method for the first time.

Professor Rây made an interesting study on the kinetics of racemization of optically active tris-biguanidecobalt (III) ion. Based on the experimental observations he suggested a simple intramolecular twist mechanism to account for the racemization. This work was reported in 1943 and is still believed to represent a probable path for the racemization of many similar inert complexes where metal-ligand bond dissociation process is energetically disfavoured. Its only serious competitor is the intramolecular twist mechanism suggested by Professor Bailar in

1957. However, the "Rây Twist" appears energetically more feasible than the "Bailar Twist". Both, however, involve the concept of distortion of the chelate rings of the metal-bound ligands, resulting in an intermediate which is not asymmetric and hence is not optically active. This, being equally unstable with respect to the d- and l- configurations, has a 50 : 50 chance to revert into the dextro- and levo-rotatory forms causing racemization.

The formation of a number of hydrogen polyhalides was studied by Ray and Sarkar by the distribution method (1922). In a large number of publications Ray and coworkers reported on the stepwise dissociation constants of the metal-biguanide complexes, studied by the pH method. The results provided much valuable information on the relationship between the stabilities of complexes and the best strengths of the ligands. Data on similar complexes of Co(III) and Cr(III) furnished, for the first time (1950-52), quantitative comparative thermodynamic data on the two metals which form a series of similar complexes with a large number of different ligands. It has been shown that Cr (III) complexes are less stable than the Co(III) complexes by about 6 kcal/mole of free energy for each stage in the dissociation of the tris-biguanide complexes of these metal ions. This difference in stability observed experimentally confirms the theoretical prediction, based on the ligand field theory, for complexes of d^6 and d^3 ions in octahedral environment of strong field ligands. The thermodynamic stabilities of the metal complexes of diglycylethylenediamine have also been evaluated by similar pH method. Several bivalent metal complexes of this ligand, which is quadridantate in character, have been prepared (1953).

HISTORY OF SCIENCES

Professor Rây was deeply interested in the History of Science. According to him: "History of Science constitutes an integral part of human civilization or of the true annals of the earth; and as knowledge and wisdom grow only on the accumulated interests of the past, it forms an essential element in the study of science itself." And so, at the instance of the Indian Chemical Society he undertook in 1956 the onerous task of publishing a revised edition of Acharya P C Rây's great book *History of Hindu Chemistry* under the title : *History of Chemistry in Ancient and Medieval India.* In this new edition much new materials were added, and all facts were carefully sifted with a view to excluding those of doubtful origin or spurious character. Reference was also made to the social and cultural conditions of the country, associated with different stages of development of chemical knowledge. He was also the chairman of the publication committee appointed to bring out Acharya Prafulla Chandra Rây's birth centenary souvenir volume, published by the Calcutta University in 1962. Furthermore, on the occasion of the golden jubilee of the Indian Science Congress in 1963, at the age of 75, Rây was persuaded to write a comprehensive account of fifty years of Progress of Science in India in Chemistry. Also as supervisor-in-charge of the History of Science Section of the Indian National Science Academy stationed at the Asiatic Society, Calcutta, he was the principal author of the English versions of the synoptic Ayurvedic texts, C̄araka Saṃhitā and Suśruta Saṃhitā, which have been acclaimed all over the world.

MEMBERSHIP OF LEARNED SOCIETIES AND AWARDS

Professor Priyadaranjan Rây was elected a Foundation Fellow of the Indian Chemical Society in 1924, and an ordinary Member of the Council in 1931. In 1933 he became the Honorary Secretary, holding the office for four successive terms. He was elected Honorary Editor for the Inorganic and Physical Chemistry sections in 1939 and served on the Board of Editors and Publication committee for more than a decade. He was elected Vice-President (1945-46) and finally President (1947-48). During the tenure of his Presidentship, the Society celebrated its silver jubilee year. Besides holding the honorary offices, he delivered the Sir P C Ray Memorial Lectureship in 1954 and Sir J C Ghosh Memorial Lectureship in 1963 of the Indian Chemical Society. He also delivered the Cooch Behar Professorship Lecture (1941) and Mahendra Lal Sircar Memorial Lecture (1960) at the Indian Association for the Cultivation of Science; Rajsekhar Bose Memorial Lecture (1963) and the Siba Priya Chatterjee Memorial Lecture (1973) at Bangiya Vignan Parishad; Shanti Swarup Bhatnagar Memorial Lecture (1968) at the Indian National Science Academy and Acharya Jagadis Chandra Bose Memorial Lecture (1971) at Bose Institute.

In 1935, he was elected a Foundation Fellow of the National Institute of Sciences in India (now Indian National Science Academy).

He was elected President of the chemistry section of the Indian Science Congress held at Bangalore on 1932. His Presidential address on "Doctrine of valency and the structure of chemical compounds" was an authoritative account of the then prevailing views on valency and complex compounds. The same year he was elected an editorial collaborator for the publication of *Chemische Analyse*, a comprehensive and authoritative treatise on Analytical Chemistry with Professor Wilhelm Böttger of Leipzig as the Editor-in-Chief. This was evidently in recognition of his significant contributions in developing new analytical methods for the detection and estimation of metals, applicable in macro and micro scales, based on the use of new reagents including complexing ligands such as rubeanic acid. It was in recognition of his contributions in developing new microchemical and colorimetric methods that he was elected in 1951 one of the seven members of an International Commission of New Reactions of the International Union of Pure and Applied Chemistry (IUPAC) and was entrusted to prepare a comprehensive and critical report in the colorimetric methods of analysis. He worked in this Commission for 8 years and when he was invited to be a member again he declined suggesting the appointment of a younger member. On being unanimously nominated President of the 20th International Conference on Coordination Chemistry in 1979, he in his usual humbleness, replied that it would have been more appropriate if an active chemist had been proposed to this coveted office. These are significant revelations of the quality of his character. In 1957, Professor Rây served as President of a national symposium on the Chemistry of Co-ordination Compounds held at Agra under the auspices of the National Academy of Sciences. He was elected President of the Indian Science News Association for the term 1958-59 and served for several years in the Editorial Board of Science & Culture. He was also a distinguished Fellow of the Asiatic Society.

He received numerous invitations to attend various international scientific conferences in USA, UK, Germany, Sweden etc. which he politely declined mainly because of his shyness about publicity.

The Universities of Jadavpur, Burdwan and Calcutta conferred on him the degree of Doctor of Science (*honoris causa*). The Indian Chemical Society felicitated him by publishing commemoration volumes on the occasion of his 75th and 90th birthdays.

VIEWS, VALUES AND IDEALS

Great as a scientist, Professor Priyadaranjan Rây was greater as a man. He was not stampeded by his researches. To us, it was most refreshing to see a top-ranking scientist stop to examine conscience. He spoke not only of science, but also of the power of love, the force of the spirit and work of humanities. His accent was not only on the problems of science, but also on the awakening of the human spirit. The test-tube cannot be divorced from the man. Man wants not only knowledge and power, but also a standard, a measure of his actions. He wants an ideology and philosophy of life, to assure him of the greatest good on earth, peace of mind. A celibate, Professor Ray roamed in the world of chemistry and soared in the sky of mysticism with equal facility. With his instinctive yearning for knowledge, he explored the explorable and quietly venerated the inexplorable.

He lived a life of austere self-denial. He was a teacher all his life, though remaining a student throughout. He was always alert about the economy of time and money and lived a life of spartan simplicity seasoned with a spirit of humility. He was chaste, self-disciplined, silent, systematic in his daily chores, fulfilled every task he undertook, treated others with love and sympathy, bore unfairness patiently and let not trifles upset him.

In the evening of his life, his failing eye-sight deserted him completely. The sense of hearing was also deeply affected. Amidst encircling gloom he groped for further enlightenment. He developed an acute yearning for spirituality. He engaged a Reader to read religious scriptures and contemporary news loudly into his ears. With his assistance he also carried on regular correspondence with self-enlightened persons like Srimad Anirvan and Sri Dilip Kumar Roy. He discussed with them questions related to human soul and divinity. The letters sparkled with Socratic logic and bore a spirit of scientific enquiry.

A few lines from his almost prophetic writings may be worth-quoting :

"In the face of the impending threat to humanity and civilization created by nuclear neurosis, we feel called upon to repeat that a new outlook in science is urgently needed, so that it may cooperate with religion and spirituality for a new order to emerge out of the travails through which the world is passing to day—an order in which the laws of morality will be as inviolable and as valid as those of nature. For this the humanity yearns."

"There is every reason to expect that science would show us the right way to peace and freedom for mankind by its rationalising influence upon human mind and human ideas."

"It is the feeling of sympathy and spirit of service alone which can make for efficiency and success; whereas high salaries in an atmosphere of scarcity, suffering and starvation become a potent cause for demoralisation at the top besides corruption and discontent at the bottom".

"Individuals must disenthral themselves from the group mentality; they have to think for themselves and assert themselves boldly against whatever is evil and hateful."

"There is an urgent need of a harmonius blending of materialism with mentalism for the good of the society. Exclusive devotion to either creates an abnormal condition in the society which becomes as injurious to its health as the abnormal growth of any part of the body as a whole."

"In reality pursuit of truth appears to be confined more or less to our scientific observations, and leaves our social, political and other relations somewhat unaffected. It should be our duty to advocate pursuit of truth in all walks of life."

"An ideology, when followed with fanatical zeal, does incalculable harm to the society like a religious faith similarly pursued."

Before the end came, he was confined to bed for several months. He lived alone in a sightless and soundless world with an angelic smile on his lips and was always serene. Not even his attending nurse could detect any sign of displeasure or grief in his countenance.

At long last, with the rising Sun on December 11, 1982, his immortal soul left his mortal frame and sojourned towards Heaven.

He reminds us of the poem of Robert Burns :
"Princes and Lords are but the breath of Kings
An honest man's the noblest work of God".

S D Chatterjee
D Banerjea

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PHANINDRA CHANDRA DUTTA

(1912–1983)

Elected Fellow 1971

EARLY LIFE AND EDUCATION

PHANINDRA CHANDRA DUTTA was born on January 31, 1912 in Agartala, Tripura, as the fifth of nine children, six sons and three daughters, to Sri Naba Chandra Dutta and Smt Rajalakshmi Dutta. The father had served as an Office Superintendent with Government of Tripura. The family originally hailed from East Bengal (now Bangladesh) and had large landed property. But fluctuations of fortunes forced them to seek their chances elsewhere and they migrated to Agartala and settled there. Sri Naba Chandra Dutta and his wife continued to live there till death and some of the surviving brothers of Professor Dutta still live in the family home at Agartala. The parents held very modern views and even in those days when it was not a common practice to send daughters to school, they provided all sons and daughters with education in equal measure. The children proved to be extremely good at school and particularly Phanindra Chandra was very brilliant. He had his schooling from Umakanta Academy at Agartala and always stood first in the class. He passed his matriculation examination in 1929 securing a scholarship and subsequently the ISc examination from Rajshahi (now in Bangladesh) College in 1931. But he had to forfeit his scholarship on account of the political upheaval then sweeping Bengal. He left Bengal and passed the BSc examination from Cotton College, Gauhati, securing first position and receiving the R K Barat Gold Medal for mathematics. After obtaining the MSc degree from the University College of Science, Calcutta in the thesis group, he was offered the Sir R B Ghosh research fellowship in 1935 to work under Professor P C Mitter, the then Palit Professor of Chemistry. At that time there was no provision for the DSc degree on the basis of joint work and D Phil/Ph D degree was not introduced in the University of Calcutta till 1948. The prevalent system was joint work for two years and independent work for the remaining one year. In the absence of any provision for financial assistance after the third year, he had to depend entirely on private tuition for mere subsistence in Calcutta. He was awarded the Nagarjuna Prize and gold medal for independent research for the year 1938 and admitted to the DSc degree of Calcutta University in 1940 on the strength of a thesis—"Synthesis of Alicyclic Compounds", adjudicated by Professor W N Haworth, FRS, NL, Professor I M Heilbron, FRS and Professor S Smiles, FRS. The Sir P C Ray fellowship was offered to him in 1941 and later he was awarded the J M Dasgupta Memorial Gold Medal of the Indian Chemical Society. He was appointed Honorary Lecturer of

Chemistry in Calcutta University in the very next year. In 1944, he was awarded the Premchand Roychand Studentship and the Mokat gold medal of Calcutta University. In the same year, ICI introduced research fellowships in India and he was its first recipient in Chemistry. In 1947, Dr Dutta proceeded abroad on a Rash Behary Ghosh travelling fellowship to work under Professor Paul Karrer, a Nobel Laureate, at the University of Zurich on anti-vitamin activities of vitamin E with incorporation of sulphur atoms. A year later he switched over to ETH laboratories of Professor Ruzicka, another Nobel Laureate, to work on sesquiterpenes, a subject which became his life-long interest. In 1949, Dr Dutta was offered a post-doctoral fellowship at Harvard University under Professor Gilbert Stork to work on the synthesis of 11-ketoperhydrophenanthrenes related to cortisone. Four years later, in March 1953 he returned to India and joined the Department of Organic Chemistry, Indian Association for the Cultivation of Science, Calcutta, as Reader and Head of the Department.

PROFESSIONAL CAREER

Dr Dutta took up the post of Reader in the Indian Association for the Cultivation of Science in 1953 and was assigned by the then Director, Professor M N Saha, FRS, the stupendous task of organizing the stripling Organic Chemistry Department. He went about this job with his characteristic missionary zeal and during his undisputed reign of 24 years, organized and uplifted the status of the Department of Organic Chemistry from a scarcely noticed entity to one of international repute. Dr Dutta became the first Professor of the Department in 1955 just before the untimely demise of Professor M N Saha. He went to UK in 1959 on receipt of a Royal Society Bursary and a Nuffield Foundation fellowship and spent four months as a visiting scientist in Imperial College of Science, London and Dyson Perrins Laboratory, Oxford to work on the structure of cascarillins. In 1962, he attended the second international symposium under International Union of Pure and Applied Chemistry (IUPAC) at Prague. He was nominated as one of the chairmen of the session on synthesis in the third symposium held at Kyoto in 1964 and travelled extensively in Japan. Same year in June, he delivered one of the invited talks in an international symposium on synthesis held at Ecole Polytechnique, Paris, and in November, proceeded to Harvard University to work with Professor R B Woodward on the revision of the structure of magnamycin. In 1966, he attended the fourth IUPAC symposium held at Stockholm. He was invited to be the chairman of one of the sessions on synthesis at the sixth symposium held in London in 1968 and in 1970 went to Russia to preside over one of the sessions in the seventh symposium at Riga and travelled in Poland and Hungary on invitations from the Polish and Hungarian Academies of Sciences for delivering lectures in different places. In 1971, he was elected a Fellow of the Indian National Science Academy (FNA) and elected to its Council in 1975.

In 1973, Professor Dutta again went to the USSR as a member of the Indian delegation to the third Indo-Soviet symposium held at Tashkent and visited Moscow and other places. In 1974, he was elected chairman at the IX IUPAC symposium in Ottawa, Canada and visited a few places in Canada and USA to deliver lectures. He spent two months as a visiting scholar in the chemistry department of Columbia University, USA in 1975 and two weeks as a visiting scientist at the State University of New York at Buffalo, USA. He represented the Indian National Science Academy at the first session of the Bangladesh Science Conference in March 1976. The following May, he spent seven weeks at Ecole Polytechnique, Paris, as a visiting Professor and in West Germany to give a lecture in Heidelberg University and two weeks as a guest of the British Council, visiting a few universities in England and Scotland for scientific discussions.

Professor Dutta had travelled extensively in the USA, Europe and Japan to give lectures and seminars on researches carried out in the department of organic chemistry. These acquaintances had helped him a lot to organize the laboratories in the Association and to fill up his 'beggar's bowl' with gift of chemicals, exhaustive experimental data on his compounds and other essential help through discussions and exchange of ideas from almost all parts of the world.

In India, he was connected with many research organizations and universities and served on various committees as expert and adviser. His association with the Central Drugs Research Institute, Lucknow as a member of the Executive Council for six years since 1967 had been particularly rewarding. With the advent of sophisticated instruments like NMR, Mass spectrometer, GLC, X-rays and computer, organic synthetic research has assumed a new dimension transforming itself from an empirical art to an exact science. With these advanced technologies, monitoring the progress of researches by micro-analysis became a less-resorted exercise although it has remained a final and confirmatory check on all new compounds before these are announced. The consequences were rather disappointing as it became pretty difficult to publish the research results from this laboratory in well-known chemical Journals. Through the courtesy of CDRI, Lucknow, instrumental facilities of that laboratory were freely accessible not only to the Association but to many other research workers of that region. The desperate situation prevailing at that time can be gauged from the fact that most of the results incorporated in the PhD theses from 1962 to 1967 could only be published from 1971 onwards. The situation, however, improved with the installation of an NMR and analytical GLC in 1974, replacement of UV in 1975 and IR in 1976, purchased in 1949 and 1957 respectively. Professor Dutta had also been responsible, through his connections and personal influences, in securing research grants from outside sources, like the chemical research committee of the CSIR, and NIH (USA) for a scheme in collaboration with Professor Alex Nickon of Johns Hopkins University. His personal influences also brought forth substantial funds from East India Pharmaceutical Works Limited, Calcutta, for meeting expenses incurred in connection with lectures organized in the Department by foreign and bright young Indian organic chemists.

Professor Dutta formally retired from his services in January 1977; but continued as Emeritus Scientist and in keeping with his phenomenal devotion to science, took up a very important project for conversion of quinine to quinidine sponsored by the Government of West Bengal.

SCIENTIFIC CONTRIBUTIONS

Professor Dutta had been a pioneer in initiating in this country, investigations into the challenging field of organic synthesis, particularly in the design of ways to negotiate the problems inherent in the synthesis of multi-asymmetric centred complex natural products. The main feature to be highlighted is the introduction of the concept of stereospecificity, developed in Harvard in late forties and early fifties for the synthesis of multi-asymmetric centred polycyclic compounds. Drawing on the abundant experience he gained while at Harvard, Professor Dutta initiated one of the most outstanding series of synthetic investigations on terpenoids. His contributions have to be viewed against the back-drop of inadequate equipment facilities and chemicals. A measure of his sustained dedication and scrupulousness can be gauged from the fact that the structures and stereochemistry he established with 'bare hands' at that time are valid till today. Professor Dutta's contributions span the whole spectrum of terpenoid chemistry and in the following pages an attempt is made to highlight the more important of these.

Sesquiterpenoids

The chemistry of sesquiterpenes, which represents under the enveloping mantle of fifteen carbon atoms, more than hundred skeletal types, had become his life long interest. He started the process of organizing the researches in the organic chemistry laboratories of the Indian Association for the Cultivation of Science with synthetic studies towards the sesquiterpene lactone, santonin, an important anthelmintic agent. One of the earliest achievements in this regard had been the stereo-controlled total synthesis of two diastereoisomers of dihydrosantonin, the synthetic precursor of this lactone. In the ensuing years he shifted emphasis to sesquiterpenes containing cycloheptane ring systems and the study on the stereo-chemical aspects of these conformationally mobile systems. Notable success in this area represents, the synthesis of a diastereoisomer of cyclocolorenone, a degradation product and model compounds related to xanthatin a few bicyclic lactones related to psilostachyns and important bicyclic intermediates to pseudoguaianolides. He utilized the concept of formation of bridged rings to control stereochemistry for a total synthesis of racemic clovane and advanced intermediates towards isoclovene and pseudoclovene-B, two important artifacts arising from caryophllene. In the late sixties he also initiated synthetic studies on the newly discovered sesquiterpenes, which culminated in synthesis of racemic sesquicaran-2-one and a key intermediate towards bakkenolide-A and fukinone.

Diterpeniods

During Professor Dutta's period and even afterwards the greatest emphasis had been given to this area and particularly towards stereo-controlled synthesis of diterpene resin acids. He started synthetic studies and made very significant contributions long before a few others entered this field abroad in the early sixties. The first phase of the investigation in this direction was devoted to transformation of a carbonyl group to a *gem*-carboxy methyl functionality with such stereocontrol that a single tricylic ketone would lead to two diastereoisomeric acids at C–4 with respect to the C–10 angular methyl group, having stereochemistry related to dehydroabietic acid and podocarpic acid. Two methods were successfully worked out and one of them led to the first stereo-controlled total synthesis of (±)-5-epidesisopropyl dehydroabietic acid.

The next phase involving studies on stereochemical course in cyclialkylations ultimately led to synthesis of racemic desoxypodocarpic acid and 5-epi-desoxypodocarpic acid. With a subsequent stereo-controlled synthesis of desisopropyldehydro abietic acid, the synthesis of all the four possible racemates was completed, with established stereochemistry. These studies helped to unravel the stereochemical uncertainties present in some of the racemates of the tricyclic acid known upto that time, besides providing a better understanding of stereoselectivities of a few reactions of general utility.

These studies were further extended and culminated in the stereo-controlled synthesis of three diastereomers of dehydroabietic acid. The optically active form of one of them, 4-*epi* dehydroabietic acid, designated as callitrisic acid, was later isolated from natural sources.

In a further series of studies a novel A-B-C ring route was developed for stereo-controlled synthesis of the C–5 epimeric pair of desisopropyldehydroabietic acid. During this time Professor Dutta and his collaborators made a remarkable discovery in the diterpene field relating to conversion of the *cis* A/B-ring junction to *trans* series of ring-C aromatic tricarbocyclic resin acid derivatives under mild dehydrogenation conditions with palladium-on-charcoal. They also completed a total synthesis of a biogenetically significant ring–C aromatic tricarbocyclic diterpene, nimbiol.

In the area of polycyclic diterpenoids, important tetracyclic intermediate related to cafestol, with proper stereochemistry was realized.. Successful syntheses of tetracyclic bridge ring compounds related to the complex diterpenoids phyllocladene, kaurene and hibaene were also completed.

The complex pentacyclic diterpene alkaloids of the garrya and atisine group posed a great synthetic challenge and a number of leading groups were involved in developing synthetic methods towards these. Professor Dutta, very early, recognized the importance of a key tricarbocyclic diacid, a degradation product obtained during the structural studies, as the proper 'junction' point for further elaboration and developed a stereocontrolled route to this diacid. Eventually this did serve as the intermediate in the total synthesis of these alkaloids by other workers. During this time, his collaborators also developed a stereocontrolled route to this diacid through a remarkable angular alkylation procedure involving ketocarbenoid insertion.

Sesterterpenes

The chemistry of sesterterpenes, comprising a net work of 25-carbon atoms and constituting the 'missing link' between di- and triterpenes did not fully emerge until the sixties when compounds containing this unit began to be isolated. Remarkably it was found that they exhibit many skeletal variations, some of them not so far encountered in the terpenoid field. This made a synthesis of these more challenging and at the same time more complex. Professor Dutta had been one of the earliest workers to enter this field with synthetic recipes and published the first paper with an approach to the perhydrophenanthrene ring system of cheilanthatriol involving synthesis of a tricarbocyclic intermediate with stereocontrol at each of the five chiral centres. Another notable achievement in this area had been the realization of a synthetic intermediate comprising a linear array of five-eight-five ring system related to the ophiobolin group of sesterterpenes.

As is evident from the achievements he had been able to realize, Professor Dutta displayed a remarkable versatility in successfully venturing into diversified fields. This had been at a time when hard work and tenacity were the only answer to long-standing problems and long before the advent of sophisticated equipments made short work of structural assignments. His success story is a measure of his dedication and long hours, that by no means came easy, and which helped him build up a great tradition, which is being upheld to this day. And it had been such dedication that prompted Professor Sir Ewart Jones to write him on his retirement, "I send congratulations on the achievement of 24 years of unremitting toil and on having 'stayed the course'. Congratulations too on your excellent work in the terpene series and for having inspired and trained so many very able collaborators. You can leave it happy in the knowledge that you and your colleagues have made valuable contributions and that you have kept the flag of research flying under far from easy conditions".

PERSONAL LIFE AND QUALITIES

Apart from being a very able researcher and research guide, Professor Dutta was a great humanist. All those who came in contact with him were deeply touched by his frankness, informality and sensitivity to the feelings of others. He ungrudgingly extended his helping hand in all possible ways to any one who approached him in need. Reportedly a good portion of his salary used to be taken away for financial assistance to those in need. A particular incident will illustrate his philanthropic attitude. One day while he was taking his usual stroll in the corridors of the department, a smart young man came upto him and touched his feet. Professor Dutta himself did not immediately recognize him until the facts were unfolded by the youth. Long ago, as a small forlorn boy, he had approached Professor Dutta for a job. At that time even though there was provision for a 'bearer' in the department, Professor Dutta could not wrangle it for the boy since he did not command much influence. So all he could do was to get him some minor job as a gate keeper with a friend of his, and arranged to get him admitted in a night school and also helped him financially through his undergraduate course. Then the boy had left Calcutta, established himself as a good accountant and migrated to USA and was in-charge of the overseas section of a multi-national organisation and on a trip to the Far East, had broken journey to pay his respects to Professor Dutta, but for whom he would not have made it in life. Instances such as this are too numerous. Where ever he went, he displayed such generosity and many were drawn to him on this account. Professor R B Woodward, the legendary figure in the domain of organic chemistry, with whom Professor Dutta worked at Harvard, had this to say in his message at the time of Professor Dutta's retirement, "It gives me great pleasure to have this opportunity to express my appreciation of the outstanding scientific, intellectual and human qualities of Professor Dutta, whose friendship I have valued for many years. May I express my warm hope that he will enjoy the many further happy years to which his contributions to science and the kindness he has always extended to his colleagues and friends have entitled him". Professor Gilbert Stork, with whom Professor Dutta was associated for four years at Harvard during his formative years, recalled, "Dear P C, I wish I could be with your friends and colleagues who are celebrating your very important contributions to the field of organic synthesis. Certainly, you became one of the most innovative masters of chemical architecture. This, obviously, contributes to the pleasure I have in recalling our association at Harvard (many years ago, though it still seems recent). But it is more particularly your personal qualities which combined an enthusiasm for chemistry, which many younger men could well have envied, with remarkable intellectual honesty, as well as your great sensitivity to the feelings of your friends and colleagues that have made the memory of our friendship over the years one I particularly value".

Professor Dutta also utilized his many contacts abroad to obtain scientific data on his sample and scarce chemicals. He used to refer to himself as the chemist with a 'begging bowl' for chemicals. Probably it was this which prompted his close friend Professor Alex Nickon of Johns Hopkins University, USA to comment, "but it was only during our close association in 1970-74 on your NIH grant that I truly appreciated the difficulties under which much of your research had been carried out, as well as your unflagging devotion to your students, to your institution, and to your profession. Before your department had spectrometers, you had to send (and even take), samples all over the world. And rumour has it that your smuggling techniques for scarce chemicals are the envy of professionals in the business".

Professor Dutta established a leading school in organic synthesis in this country and fortyfive students obtained the PhD degree under his guidance and another twenty were associated with him professionally. All of them have successfully established themselves in academy and industry. Some of the more illustrious names in the academic field are Professor U R Ghatak, a synthetic organic chemist and one of his very early collaborators, and who incidently succeeded him on his retirement as Head of the Department, Professor S A Narang of National Research Council, Canada, who subsequently shifted to biochemistry and carved out a niche for himself, Professor J R Mahajan of University of Brazil, Dr S L Mukherjee, Vice-President, INFAR (formerly Organon) India Limited, and Dr P K Ramachandran, Director, Defence Research and Development Establishment, Gwalior.

He married Smt Chhabi Sengupta in 1943, who established herself as a leading microanalyst, having trained in Switzerland, and subsequently organized the microanalytical laboratories of the Indian Association for the Cultivation of Science. They have only one child, a son, Sudhin, who has also shown the same brilliance of mind and aptitude for science. He completed his PhD in chemistry from Harvard University and is at present with Exxon Corporation, USA.

Professor Dutta led a very unostentatious life. His needs were few and he shunned luxury, but never forced his spartan habits on others. Besides looking into the various administrative problems as Head of the Department, he also found time to work with his own hands and prepare starting materials for his students. This was a habit he continued right upto his retirement and his associates very much miss the familiar figure, down to his vests in summertime, carrying out laborious bulk distillations and other experiments. He used to be one of the earliest to come to the laboratory and one of the last to leave, many times after well past 8 pm. Such dedication served as a source of inspiration to all his associates.

After his formal retirement, true to his incessantly active habits, he took up a project for chemical transformation of quinine to quinidine sponsored by the Government of West Bengal and was involved with this till his death. Even though he completed the task successfully he did not live to see the setting up of a pilot plant on his process.

After his son left abroad, his wife also soon joined him. But Professor Dutta steadfastedly refused to leave his country and during his last years was looked after by his spinster sister Smt Leena Dutta, who is a Government Marriage Registrar. Smt Dutta, along with another sister Smt Binapani Deb, who is a teacher in Victoria Institute, Calcutta, had been actively involved in the freedom struggle and also suffered imprisonment. These services have been recognised by Government of India and they are worthy recipients of the Freedom fighter's pension. The high noon over, the strains of the years took their toll and Professor Dutta was rendered weak, and yearned for filial company which eluded him. He grew progressively pensive and weak and was bed-ridden briefly till the end came on June 13, 1983. Many of the present staff of the Department of Organic Chemistry, Indian Association for the Cultivation of Science, who were his associates and continue on his great tradition, bear living monument to his dedication and contributions.

ACKNOWLEDGEMENTS

Much of the material in this biographical sketch has been drawn from 'Phanindra Chandra Dutta, an inspiring career', a brochure brought out by the students and admirers of Professor Dutta at the time of his retirement, in 1977 and 'Century', a volume brought out at the time of the Centenary Celebrations in 1976 of the Indian Association for the Cultivation of Science. The authors would like to thank the sisters and brothers of Professor Dutta for information on his early life.

R V VENKATESWARAN
U R GHATAK

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RAMANLAL CHHAGANLAL SHAH

(1899–1969)

Elected Fellow 1941

EARLY LIFE AND EDUCATION

RAMANLAL CHHAGANLAL SHAH was born on October 7, 1899 at a small place called Pardi, nestling among mango groves, a few miles from Bulsar in South Gujarat. He was the elder of the two sons. His father was in railway service and worked as a station master. Transfers were inevitable and young Shah studied in the schools at Baroda and Navsari. The matriculation examination was then conducted by the University of Bombay for the whole of the then Bombay state. Shah who had at times to study under municipal lamp posts, stood fourteenth in the matriculation examination and was first amongst the students who appeared from the then Baroda state. He then joined the Gujarat College at Ahmedabad. He later went to Bombay and studied at the Wilson College and took the BA degree of the Bombay University in 1920 with first class honours in Physics and Chemistry. Shah was appointed a Fellow at the Wilson College and he took the BSc degree of the same University in 1921. He was influenced by Professor K C Pandya to choose chemistry as his subject for further study. A post-graduate research scholarship took him to the Indian Institute of Science at Bangalore which was then the Mecca of all brilliant research students in science. He worked there in the Department of General and Organic Chemistry under Professor J J Sudborough. Shah was awarded the MSc degree by the Bombay University for his thesis which also won for him the Moos Gold Medal of the University. He was admitted to the Associate membership of the Indian Institute of Science in the same year.

PROFESSIONAL CAREER

Shah joined the educational service of the Bombay Government in 1925 and was posted at the then Royal Institute of Science in Bombay where he worked till 1929. It was at about this time that he married Kusumben the daughter of a business man. The Mangaldas Nathubhoy Foreign Scholarship of the University of Bombay enabled him to work with the distinguished chemist, Professor Robert Robinson, at the University College of London. Professor Robinson soon left for Oxford, and Shah had to join the Dyson Perrins Laboratory at Oxford to complete his work. On his return to India after getting his doctorate of the University of London in 1931, he was appointed Head of the Department of Chemistry in the Ismail Yusuf College which was newly started by the Government of Bombay. Although this college was only upto the intermediate stage, Dr Shah never lost touch with research and he continued to take research students at the Royal Institute of Science.

R C Shah

This was made possible due by the generosity of Dr T S Wheeler, who was then the Professor of Organic Chemistry and Principal of the Royal Institute of Science, and who held Dr Shah in high esteem. With the departure of Dr Wheeler in 1939 Dr Shah was transferred to the Royal Institute of Science as Professor of Organic Chemistry. There he remained for 12 years and built up a flourishing school of research in organic chemistry. MSc was then a research degree and over 50 students took their MSc degree and over 25 students took their PhD degree under his guidance.

In 1950, Dr Shah was invited by the Council of Scientific and Industrial Research to join the newly started National Chemical Laboratory (NCL) at Poona as an Assistant Director and Head of the Organic Division. He became the Deputy Director of NCL in 1959. He retired in 1961 but continued to take a good deal of interest in industrial development and acted as an adviser to a number of pharmaceutical and chemical industries.

SHAH AS A TEACHER

Dr Shah was an excellent teacher. His exposition was lucid and the teaching material up-to-date. He used to show many experiments in the class which enhanced the interest in his lectures. There were two very serious accidents during these lecture demonstrations. On one occasion while demonstrating the properties of hydrogen, he lighted the hydrogen at the end of a tube, the flame struck back, there was an explosion and the glass hydrogen generator was smashed to pieces. Fortunately no one was injured. On another occasion, he was demonstrating the coloured flames using different salts, the mixture flared up and burnt his hand. The burns took more than two months to heal. Unknown to him an over enthusiastic laboratory assistant had mixed magnesium powder with the salts to make the demonstration more spectacular. Undeterred by these accidents he continued his lecture demonstrations. His lecture table was full of models, charts and lecture demonstration equipment. He enjoyed till the end of his teaching career lecturing to undergraduate classes making abstract ideas and principles so easy to understand. He never wrote any text book despite lucrative offers. It can be said of him without any hesitation that—

> "The beauty of his better self lives on
> In minds he touched with fire, in many an eye
> He trained to Truth's exact severity;
> He was a Teacher,
> Whose living ward still stimulates the air."

Dr Shah's research work was extensive and varied. He worked in the field of pure as well as applied chemistry. He published over 150 research papers and was granted 13 patents In his generosity he allowed his students to publish some papers under their own names and to continue work independently in the fields in which he had initiated the work. He took delight in getting pure crystalline material from pastry, tarry, intractable material and each one of his research students had to keep a dozen dry test tubes and an equal number of glass rods, a pocket lens and a number of solvents ready when he took his round in the laboratory. He was very generous towards his research students and never nagged them for results. When he found that a student was sincere worker he gave him ample scope for developing his own talents and had a word of appreciation when an interesting result was obtained. Nevertheless, he was very critical of students who were lazy and careless in their work and such students very often left in the first year of their research.

RESEARCH CONTRIBUTIONS

In pure chemistry his work is both in the field of natural products and on the synthetic side. In the field of natural products he studied the chemistry of oroxylin, a constituent of the root bark of *Oroxylum indicum* Went; wogonin, a constituent of the roots of *Scutellaria baicalensis*; calycopterin, a constituent of the leaves of *Calycopteria floribunda*; cardanol, the main constituent of the cashew nut shell liquid and pristimerin, isolated from the root bark of *Pristimera indica*. The chemical examination of the indigenous medicinal plants *Swertia decussata* and *chirata* was carried out and the structures of swertinin and decussatin established. Geijerin, a naturally occurring coumarin derivative and dihydrorobinetin were synthesised. New syntheses of neaturally occurring hydroxyxanthones, lichexanthone and gentisein, were also developed. Much of Professor Shah's work on natural products was done at a time when the present day techniques of cromatography, microanalysis and spectral analysis were either not developed or were not available in India. Prior to the second world war the compounds were sent to Germany for microanalysis, a facility which stopped when the war broke out. During the war some compounds were analysed at Oxford and others at Lahore where Professor J N Roy had started a microanalysis unit. The establishment of the structures of natural products could only be done through degradation and synthesis. Almost all the fine chemicals including solvents had to be imported from UK or Europe and as they came by ship they took several months. The research grants and fellowships were very meagre and many research students had to do their research work on a part-time basis along with some other job.

On the synthetic side, his work lay in the synthesis of various imidochlorides and study of their reactions; γ-substitution in the resorcinol nucleus and studies on the fixation of double bonds in the aromatic nucleus; studies in the synthesis of various oxygen heterocycles such as coumarins, chromones and flavones and nitrogen heterocycles such as quinolines; studies on the pattern of substitution in various oxygen heterocycles; and synthesis of C-alkyl-resorcinols. He developed the use of anhydrous aluminium chloride dissolved in dry ether in the Gattermann reaction on some resorcinol derivatives and obtained γ-substitution in the resorcinol derivatives. When he used anhydrous aluminium chloride dissolved in dry nitrobenzene as a condensing agent in the Prechmann condensation of ketonic esters with some resorcinol derivatives such as methyl resorcylate and resacetophenone he obtained

5-hydroxy coumarin derivatives which are otherwise difficult to obtain. It was because of these interesting results that his friends called this reagent 'Dr Shah's magic wand'. Later, at the NCL, he developed the use of a mixture of anhydrous zinc chloride and phosphorus oxychloride as a condensing agent. This reagent has been found to be remarkably effective for the synthesis of a variety of organic compounds such as hydroxy xanthones, arylalkylketones, deoxybenzoins, chalkones, 4-hydroxycoumarins and 2,4-dihydroxy quinolines. New applications of lithium aluminium hydride and boron trifluoride were also worked out.

Dr Shah was keenly interested in industrial problems. In the thirties he worked as the Secretary of the Chemicals Sub-committee of the National Planning Committee set up under the inspiration and guidance of Shri Jawaharlal Nehru. In the early forties, he investigated the manufacture of saccharine and chloramine-T. His process for the manufacture of chloramine-T was taken up by the Government of India during the second world war for the manufacture of antigas ointment and a reward was given to him. His services were lent by the Government of Bombay to the Government of India during the second world war. He served as the Development Officer (Antigas) during 1942-43 and in that capacity established the manufacture of chlorosulphonic acid at Mysore Chemicals and Fertilizers Ltd., for the Government of India. He served as the Deputy Director of Chemicals in 1943-44 in the Supply Department of Government of India.

Professor Shah developed a new synthesis of 4-hydroxycoumarin, the key intermediate for the manufacture of blood anticoagulants such as dicoumarol and warfarin. The latter is also used extensively as a rodenticide and its manufacture was undertaken by a firm under the guidance of Professor Shah. Among the other work initiated by him personally may be mentioned the preparation of thymophthalein which was considered at one time a potent colouring matter for ghee obtained by hydrogenation of oils to prevent adulteration of pure ghee with hydrogenated oils; industrial utilisation of sugar cane wax and development of a cheap oxidizing agent for oxidation of nicotine sulphate to nicotinic acid. A number of other problems were tackled under his general supervision at the National Chemical Laboratory.

AWARDS AND HONOURS

Honours came to him in abundance but he never went after them. He was elected Fellow of the National Institute of Sciences of India (now INSA) in 1941. He was a Fellow of the Indian Academy of Sciences. He presided over the chemistry section of the Indian Science Congress in 1951 and over the Science Section of the Gujarati Sahitya Parishad in 1949. He was the recipient of Acharya Prafulla Chandra Ray Medal of the Indian Chemical Society and of Dr K G Nail Gold Medal of the MS University of Baroda, awarded for research work in the field of applied chemistry. He was the President of the Indian Chemical Society for two years and a member of the Pharmaceutical Enquiry Committee of the Government of India (1952-54). He was deputed by the Council of Scientific and Industrial Research to visit England and the continent in 1954 to see various university and industrial research laboratories to study newer developments in organic chemistry. He was elected chairman for some of the meetings of the International Union of Pure and Applied Chemistry held at Zurich in 1955.

SHAH AS A PERSON

Professor Shah was quiet by nature and of a rather retiring disposition. As an administrator he was very kind and sympathetic and showed great consideration towards those who worked with him. When he entrusted some work to a person, he had full responsibility for the same. He never raised his voice in anger or made any disparaging remarks. He never made a fetish of trivial incidents of lapses on the part of those who worked with him. It was always a pleasure to work with him. In research work he was very exacting and wanted precise information on the experiment done. He could at once find out through a few questions whether the research worker was truthfully reporting the results or bluffing.

Dr Shah commanded great respect. His relations with his former students were cordial. In their company he relaxed and talked freely about many things amongst which were educational matters and need for more young men starting small scale chemical industries. His latent sense of humour came out on such occasions. His advice to his students, though sometimes cryptic, were very useful. To a student who got his first appointment as a demonstrator he said "keep out of politics as I have done". To another who used to talk incessantly his advice on taking up an appointment was "talk only when you must".

He was very keen on the maintenance of high standards in our universities and wanted good, dedicated teachers to be appointed. He used to say that "If you select a bad research worker the damage will be limited. At the most he will not work but if you select a bad teacher you harm generations of students." He was known to objectively evaluate even his own students and did not hesitate in recommending an outsider for appointment if he was found superior in qualifications and performance.

Since his retirement he stayed in Bombay and he was quite happy and relaxed. His two sons and a daughter are happily settled. Mrs Shah, whose kindness and grace all those who have known her admire, looked after him with tenderness and great care and we all hoped he would live for many more years to come. It is very sad that the end came so suddenly and without any premonition.

To a large number of students, friends and admirers of Professor R C Shah the news of his sudden death after a heart attack on September 3, 1969 came as a great shock. They were planning to celebrate his 70th birthday on October 7, 1969 in a big way. In his death the country lost a good citizen whose patriotism took the cencrete shape of application of the results of his work for the production of chemicals the country needed. The world of science lost a sound organic chemist whose research was not motivated by the prospects of material gain or intellectual snobbery or desire for social prestige but by the sheer love of it. We who had the privilege of knowing him and working with him over years mourn the loss of a genuine well wisher and a warm hearted personality.

Suresh Sethna

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S V Chakravarti

SATYENDRA NATH CHAKRAVARTI

(1903–1945)

Elected Fellow 1935

BIRTH AND EDUCATION

SATYENRA NATH CHAKRAVARTI was born in 1903 in Calcutta. After a distinguished career at Lucknow University where he obtained his master's degree in chemistry, he went in 1926 to Oxford, England to work with Professor W H Perkin Jr, FRS, at the DYSON Perrins Laboratory.

CHAKRAVARTI AND ANNAMALAI UNIVERSITY

After obtaining his D Phil degree he returned to India in 1929 and took up the Headship of the Department of Chemistry at the newly started Annamalai University at Chidambaram, South India. With his unbounded enthusiasm and passion for organic chemical research, he lost no time in setting up an active research group around him. He worked heart and soul to enthuse the students around him in chemical research. He also proved himself to be a great teacher and also an administrator. Many of his students have often recounted with great feeling the personal interest he showed in their progress and the attention which he gave to even the minutest detail whether in administration or teaching. Professor Chakravarti worked at a time in South India when only the Presidency College, Madras had a well-developed Honours programme in chemistry. The task of developing an Honours course at Annamalai University, fell to him, a task which he carried out with great efficiency and dedication. The momentum which he gave to teaching and research activities in the chemistry department in those years in a way provided inspiration for others who succeeded him. The Chemistry Department at Annamalai University has as a consequence since maintained an unbroken tradition of high standards both in teaching and research. Professor Chakravarti was not only a hard working and enthusiastic teacher-cum-chemist; he was also popular with both students and staff members. No wonder he was elected by fellow syndicate members to be the acting Vice-Chancellor of Annamalai University for a few months.

He trained several students to obtain their MSc degree by research under his supervision. Several of his students later rose to high positions in industrial, academic

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*The memoir is based essentially on obituary notes published in Indian Journal of Chemistry (254, 1945) and Journal of Chemical Society (Britain) 840 (1946) by Dr M Swaminathan and Dr K Ganapathi respectively—themselves students of Professor Chakravarti.

and also government institutions. Ever since the day he took up the reins of office, there was a steady stream of research publications from the Chemistry Department of the Annamalai University. As a student of W H Perkins Jr during his Oxford days, Professor Chakravarti was involved in studies related to Berberine, Tetrahydroberberine and Protoberberinium salts. Several of these studies were given new directions by Professor Chakravarti at Annamalai University and during the seven years or so that he served at Annamalai University he published about 28 papers in International and Indian Chemical journals. Stated briefly, his papers deal with syntheses of isomers of tetrahydroberberine, a new method of synthesis of substituted phthalonic acids, synthesis of paraberine, homopthalic acids, ψ—opionic acid and related studies. He also carried out chemical investigations of several Indian medicinal plants published mostly in the Journal of Annamalai University.

CHAKRAVARTI AS A FORENSIC SCIENTIST

To the great loss of the academic world, Professor Chakravarti moved in 1935 to Agra as Chemical Examiner to the Government of the United Provinces and Central Provinces. In his new position, he turned his attention to forensic chemistry and published several papers of analytical interest such as methods of determination of arsenic content in human bones and ashes, methods to distinguish between various types of opium preparations, methods of estimating cocaine in mixtures with other drugs etc. He was author of 42 original publications altogether. He was a Fellow of Indian Academy of Sciences, National Institute of Sciences of India and also a Fellow of Royal Institute of Great Britain and Ireland. He also served as a Member of the Council of Indian Chemical Society for two terms.

CHAKRAVARTI AS A MAN

Professor Chakravarti was loved by all. Many of his students often speak of his modesty, honesty, dealings with others and also his courage and independence. He gave freely of his advice to those who sought it. Professor and Mrs Chakravarti were great hosts and his fellow staff members and students used to enjoy their hospitality quite often. Professor Chakravarti was fond of playing bridge in which he used to excel.

It is unfortunate that a promising career like that of Professor Chakravarti ended in tragic circumstances on August 28, 1945. In his untimely death, India lost one of the most active and motivated organic chemists of his generation. He left behind his wife, four children and a very large number of friends to mourn his loss.

S SWAMINATHAN

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RANGO KRISHNA ASUNDI

(1895-1982)

Elected Fellow 1951

INDIA has a great tradition in spectroscopy and was in the forefront with discoveries of Raman Effect for the elucidation of molecular structure and Saha's ionisation formula for understanding the stellar spectra. To this generation belonged Professor RANGO KRISHNA ASUNDI, who was one of the pioneers in molecular spectroscopy and endeavoured to develop spectroscopy as an important field of basic research.

EARLY CHILDHOOD AND EDUCATION

Born on August 14, 1895, Rango Krishna Asundi hails from a village which bears their family name, Asundi near Gadag in Dharwar district of Karnataka. Early in his childhood the family of Asundi moved to Gadag (1902) and then to Dharwar (1909) where the young Asundi had his primary and secondary education respectively. He passed his matriculation examination of the Bombay University in 1912, standing first in Dharwar district. This provided him a Dharwar scholarship to pursue his collegiate studies in Pune. He took his first degree of BA (Hons) with Physics and Chemistry in 1917 from Deccan College. Subsequently, he joined the staff of the Fergusson College from where he took his second degree of BSc (Physics) in 1919.

DEDICATION TO SERVE KARNATAKA EDUCATION SOCIETY

Asundi realised the need for establishing higher educational institution in old Bombay Karnataka, the absence of which made him go to Pune from his own native district of Dharwar. When the Karnataka Education Society, Dharwar started, he joined it as a Life Member in 1919 and resolved to dedicate his services to a teaching career in Dharwar. He first joined as a teacher at Victoria High School and one year later, when Karnataka Education Society started a college, joined as a Professor of Physics along with Principal P S Katti, a senior wrangler in mathematics from Cambridge (who was formerly at the Dacca University along with Professor S N Bose). When they started collecting funds, they found enthusiastic support from Dharwar and within a year they had an enviable record of students rushing to their college in preference to the government college in Dharwar. Thus, their dream of building a premier college of university education in Karnataka seemed to be coming true. However, when the college had hardly come into existence in 1920, the non-cooperation national movement started against the British rule with the first plank of operation to boycott the schools and colleges. In the wake of this agitation, they had to close down the college and thus the young Asundi had to leave Dharwar for Bombay in 1921.

While at the KES college, R K Asundi took active interest in the history of Karnataka and wrote articles highlighting the grandeur of Karnataka, its culture and literature, the poetry of Purandara and the great women of Karnataka. He served as the honorary secretary of the Karnataka Historical Research Association (1919-1921).

PURSUIT OF RESEARCH CAREER IN PHYSICS

As R K Asundi decided to leave Dharwar for further studies in Bombay his eldest brother, A K Asundi who was serving as a District Judge of Bombay Province advised him to study law and later try for a position of a sub-judge in the judiciary of the Bombay State. But he was more interested in an academic career and so contrary to the wishes of his brother, he went to Bombay for post graduate studies in physics.

Asundi joined the Wilson College, Bombay first as a Lecturer (1921) and later as an Assistant Professor of Physics (1924). He did his research work with Professor A R Normand and submitted a thesis entitled *Boiling Points of Solutions in Methyl Alcohol under Reduced Pressure*'. This work was recognized as a commendable piece of research which not only won him the MSc degree of the Bombay University with distinction but also the Sardar B R Akbarnavis Foreign Research Scholarship of the University for higher studies.

Asundi proceeded to London in October 1927 to work in O W Richardson's Laboratory at King's College. He soon started working with the R C Johnson on molecular spectroscopy and in two years he could finish his work for the PhD degree of the London University. He acquired great skills in experimental techniques for the excitation of molecular spectra. His main contributions were in the identification and characterization of electronic states of CO molecule. One of his first discoveries in the CO molecule was the $C^1\Sigma^+ — A^1\Pi$ system. Asundi did fine structure analysis of the bands and identified the transition to be $^1\Sigma — {}^1\pi$ type. This band system was also discovered at the same time independently by G Herzberg. These bands were then known as Johnson-Asundi-Herzberg bands. His guide Dr R C Johnson was so much excited with the discovery of the new CO bands that he rushed post-haste for its publication in the *Proceedings of the Royal Society*. During the same year, Asundi discovered a second band system of $a'^3\Sigma' — a^3\Pi_r$ which is known after him as 'Asundi bands'. Soon afterwards, he studied the so called high pressure carbon bands which were attributed to CO, CO^+, CHCH etc. and showed that they had the same final level as the Swan system of C_2, thus providing the correct identification of the emitter to be the homonuclear diatomic C_2 molecule. Thus, during the short period of his stay at King's College he had very important contributions which made him a pioneer in the field of molecular spectroscopy.

Drs K Rangadhama Rao, S Ramachandra Rao and I Ramakrishna Rao were also doing research in allied fields of spectroscopy in London and Asundi was a close associate of them. After completing the Ph D requirements of the London University, Dr Asundi spent a few more months studying spectra of diatomic molecules of interest at that time. Before returning to India, he visited some of the reputed spectroscopy laboratories in Utrecht, Eindhoven Amsterdam, Leyden, Bonn and Berlin.

At Aligarh Muslim University

On his return to India in May 1930, he was naturally looking forward to serve in a university where he could continue his research activity in molecular spectroscopy. He had to wait several months before he had an invitation from Professor R Samuel who was then working at the Aligarh Muslim University. He accepted an appointment from the university which provided him with an opportunity to set up an excellent spectroscopic laboratory at Aligarh which was soon recognized as an active research centre and often visited by Professors M N Saha and K S Krishnan. They had trained several students for research in spectroscopy for doctoral work during 1931-1938. The most significant publications from Aligarh were related to dissociative energies and the structures of molecules, SO_2 and SiF. However, when Professor Samuel returned to Israel in 1938, Dr Asundi's contract was also terminated. He, therefore, had to look for a job and wait for several months.

At Banaras Hindu University

Pandit Madan Mohan Malaviya, the founder Vice-Chancellor of the Banaras Hindu University (BHU) had learnt about Dr Asundi earlier and was, therefore, very glad to offer him a Professorship in BHU. Professor Asundi narrates in one of his reminiscences how much he was impressed when he first met Panditji and from then on, he felt that he should contribute his best for the great institution that Malaviyaji created in Banaras. In the early years of his joining BHU, he had to contend with meagre facilities for spectroscopic research. However, being an excellent experimentalist he started designing and fabricating spectrographs and excitation sources to obtain emission spectra not only of several diatomic molecules, but also of polyatomic molecules such as benzene, toulene, benzaldehyde, benzoquinone, benzonitrite etc In the latter studies of benzene, several Fermi resonances were discovered and correctly explained. Very soon, the laboratory was full of activity with discoveries and interpretations of new electronic band system in CO, CO^+, I_2, Br_2, CI_2 and the continuous emission bands of fluctuation type in I_2, I C_1. Professor Asundi's contributions were soon recognized by successive Vice-Chancellors, particularly Acharya Narendra Deva and the university created an independent Department of spectroscopy which has, over the years, grown into a good school of spectroscopy in the country.

At Bhabha Atomic Research Centre

On learning that Professor Asundi was to retire from Banaras Hindu University at the end of the academic year 1955-56, Dr H J Bhabha invited him to join the Department of Atomic Energy as an Honorary Adviser. He readily agreed and moved over to Bombay in February 1957. The very first task that he undertook was to build a spectroscopy laboratory so that it could provide sensitive and reliable analytical service of nuclear materials. He has simultaneously organized research activities in atomic, molecular and crystal spectra. Optics was an essential component of spectroscopic instrumentation and so a section of optics was added into the design and fabricate high quality optical components like Fabry-Perot plates and sophisticated lens systems. Professor Asundi devoted time to do research himself in addition to supervising the work done by the spectroscopy group. Resulting from his work were many research publications such as (i) The identification of the fluorescence spectrum of neutron irradiated monocesium uranyl nitrate as that of di-cesium uranyl nitrate (involving the synthesis of di-salt for the first time) and (ii) The evaluation of ionisation potential of oxygen molecule.

Thus, 'subsequent to his retirement from BHU, he worked vigorously for another twentyfive years and helped establish one of the finest laboratories at the Bhabha Atomic Research Centre in Bombay.' (Quoted from a tribute paid at the Annual Conference on Molecular Spectroscopy and Molecular Structure at Columbus, USA in June 1982)

The Department of Atomic Energy (DAE) established a Board of Research in Nuclear Sciences (BRNS) with an Advisory Committee in Physics to support research through grants and Professor Asundi was appointed as its Chairman in 1957. It was during his tenure (1957-62) that the annual symposium on Low Energy Nuclear Physics (under the sponsorship of DAE) was started. This has now considerably extended and continues to meet in large numbers in two major groups of Nuclear Physics and Solid State Physics at several universities and research institutes actively engaged in these areas.

Dr Bhabha entrusted to him the work of Disarmament Study Group in 1962 which used to meet regularly at the Tata Institute of Fundamental Research. He was associated with this activity upto 1966.

Professor Asundi believed in international association in research and persuaded Dr Bhabha to invite such eminent scientists as Professors R S Mulliken, G Herzberg, A Kastler, J Lecomte, H Sponer-Franck, J Rud Nielsen, P Swings, G H Dieke and P Jacquinot who spent a few weeks to several months in Bombay as distinguished Visiting Professors, gave illuminating lectures and participated in the research work of the Division.

Professor Asundi organized the first International Symposium on Spectroscopy in January 1967 which was attended by most of the active spectroscopists of the world. In honour of Professor Asundi, a one day symposium was held during this conference when all the participants lauded the excellent work done by him and admired the success with which he was building a new spectroscopy laboratory in Bombay.

Professor Asundi was all along actively associated with the academic bodies of several universities and Institutes of Technology, particularly, Powai and Kanpur, and the Research Councils of CSIR laboratories. Though he was critical in evaluating persons for appointment/promotion or research projects for support, he always offered constructive and helpful comments. While referring theses or papers for publication, he would have checked meticulously all calculations, references and experimental details and only then gave his recommendations with full justification. He lamented the deteriorating standards and quality of research. He felt that support and encouragement for fundamental research were inadequate. He stressed the importance of spectroscopy as one of the basic sciences with very wide applications in physical and life sciences. This conviction strengthened with his every participation in many international symposia *e.g.* at Montreal at the International Astronomical Union (IAU) meetings or at the Royal Society meeting on 'Molecules in Interstellar Space'. He appealed for large support for spectroscopy and greater interaction among spectroscopists.

Professor Asundi was one of the pioneers in molecular spectroscopy and made many significant contributions. He was a Fellow of several Scientific Academies and honoured with Academy awards. He was elected Vice-President of the Indian National Science Academy, Council Member of the Indian Academy of Sciences. President of the Indian Physical Society, Founder-President of the Convention of Spectroscopists of India and President of the Physics Section of the Indian Science Congress. He was also a Member of the American Physical Society and the Optical Society of America.

He visited several laboratories in USA and Canada and participated in the international conferences in India and abroad. He was a distinguished Visiting Scientist at the National Research Council, Ottawa and MIT, Cambridge, and visited both very often. He was a special invitee for the International Symposium on Atomic and Molecular Quantum Theory held in January 1965 in Sanibla island in honour of Professor R S Mulliken and for felicitation to Dr (Mrs) Charlotte E Moore of the National Bureau of Standards, USA. He was also invited to an International Symposium, on van der Waal's molecules held in honour of Dr G Herzberg in Montreal at the time of meetings of IAU. Eight months before he died, he attended a Royal Society meeting in London of a select group of spectroscopists as a special invitee.

Professor Asundi delivered the M N Saha Memorial Lecture (1964) of the Indian Physical Society, the first K S Krishnan Memorial Lecture of INSA in 1970 and the first INSA K Rangadhama Rao Memorial Lecture in 1980. The Kannada Sahitya Sammelan of Karnataka Sahitya Parishat in Dharwar elected him with President of its science section. In 1973, that Kannada Sahitya Sammelan honoured him with a citation and an inscription VIGNAN-SUGNANA SANGAMA on a copper shield.

ASUNDI AS A TEACHER

Professor Asundi was a great teacher. His affection and love towards his students were such that each one would think that he alone was his favourite. Indeed, all his students in India and abroad always eagerly looked forward to his visits, since all their families would enjoy his company. The children remember him as the grandfather to whom they could listen with absorbing interest about the great Indian heritage and learn the constellations of stars in the skies. He was a man of great humanism and an affectionate companion. He helped many students all through his life. Many stayed with him like members of his family.

ASUNDI AS A MAN

Professor Asundi was very active and spent his time reading or writing articles on science, literature and philosophy. He had gone through many hardships in life but always worked and hoped for better things. He never bore ill-will or animosity towards those who denied him his due. He was a true friend and loved one and all.

Professor Asundi was as deeply interested in religion, philosophy and sanskrit literature as in science. He gave discourses on Bhagavat Gita and Madhva philosophy. His article on (the unforgettable) Mahamana Pandit Madan Mohan Malaviya and the convocation address at IIT Kanpur, bring out the greatness in him and his appreciation of human values, spiritual and moral.

Though Professor Asundi hailed from Dharwar, he developed an intense love for Banaras and the river Ganges. He acquired a plot of land close to the river at the University Ghat to settle there after his retirement from the Banaras Hindu University. He, however, left for Bombay when Dr Bhabha invited him. As long as he was in the university, he used to go every day early in the morning even in rainy weather or cold winter, to Ganges to take his bath and in fair weather to swim almost half-way across the river.

Professor Asundi was the youngest of three brothers. He had great respect and affection for his eldest brother A K Asundi who worked as District Judge in the old Bombay State and took parental care and guided his career throughout. During his Vice-Presidentship of INSA, Professor Asundi got an Endowment of Rs 16,000 (a donation from his brother) to INSA to institute Shree Dhanwantari Prize. Professor Asundi lost his wife very early before he left for England for his doctoral studies. He had only one son, Krishna R Asundi, who is an aeronautical engineer working in Air India and one granddaughter and two grandsons.

On 2 February 1982, on the sacred Maha Navami day, Professor Asundi died at his home in Santa Cruz. He was to have participated in the discourses at the Ahobila Mutt on that day. The scientific community has lost a spectroscopist of world repute, a man of wisdom and of great human qualities.

N A NARASIMHAM

PS : The Editor, Dr G S Venkataraman fondly remembers this great man during his BHU days as a friend, philosopher and guide and pays respectful homage to this great soul.

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ARTHUR LENNOX COULSON

(1898–1955)

Foundation Fellow

ARTHUR LENNOX COULSON (Lennox after his ancestor Lord of the Isles) was born on January 25, 1898 at Elsternwick, Victoria, where his family had a Victorian villa on large grounds including a tennis court. His father owned, with his brother, Coulson Carriers for customs and general carriers, later on of oil, fuel, etc. Both brothers were owners in the firm. Coulson was the middle son of a family of four; three boys and one girl.

He went to Caulfield Grammar School where in due course he followed the example of brother Will and was the Dux of school and a member of the Cricket XI and the Football XVIII. He was admitted to the Melbourne University at the age of sixteen as an undergraduate in science, majoring in geology. He broke his university studies to enlist in the Australian Infantry Forces as a private in the first World War. In 1919, he resumed his studies in Melbourne. J A Dunn became a fellow student in the same year. After obtaining his BSc, Coulson continued on post-graduate work for his MSc in 1920 and 1921. Award of Kernot Research Scholarship and the Wyselkie Scholarship for Natural Sciences in Geology enabled him to proceed to London, where he joined the Imperial College of Science for further post-graduate work and on which he was awarded the Diploma of the Imperial College (DIC). Latar in 1933, Melborne university Conferred on him the DSc degree.

SERVICE IN INDIA—POSTS HELD

From London he was appointed to the Geological Survey of India which he joined in November 25, 1922 as Assistant Superintendent (now known as Geologist). During his career in the Survey, he was the Curator (1927-1929), the Assistant Director (1932-1934), and then acted for a short time as the Palaeontologist (1934). He was promoted as the Superintending Geologist in 1936, having previously officiated in that grade for short term during 1930, 1932 and 1939

SCIENTIFIC CONTRIBUTIONS

In the Geological Survey of India, Coulson was attached to the Central Indian Coalfields Railway's Survey Party during the season 1922-23. His reports, submitted to the Railway Board in 1923, and to various other bodies are characterized with meticulous details.

His field work in India is broadly divisible into two parts—the years to the end of 1930, spent mainly in mapping in Bundi and Sirohi States, Rajputana and the later years from the end of 1935, spent in the North-West Frontier Province, Waziristan and Kashmir. The results of his early years of mapping are best known from his paper on Bundi, published in the *Records,* and his *Memoir* on Sirohi. In Bundi, rocks are mostly shales, slates, phyllites, limestones etc. The phyllites have abundant mica and occasionally well twinned crystals of staurolite. Some limestones approach marble in physical features and are used extensively as a local building stone. Coulson's most extensive geological survey has been in Sirohi. The chief geological interest lies in its igneous rocks, whether intrusive or extrusive. Across the centre of the area, lies a belt of ancient schists irregularly interrupted by tongues or intrusive Erinpura granite and its associates.

After completing the geological survey of yester Bundi State in Rajasthan, Coulson commenced the survey of yester Sirohi State of which Mount Abu is the most fantastic landmark of the region. It is made up of Erinpura granite, strongly foliated gneissic rock, the relative eminence of which is perhaps due to dominance of biotite which facilitated the more ready weathering of the rock than the surrounding rock types. He completed the survey of Sirohi in the field seasons 1925-27. During 1927-29, he was stationed in Calcutta as Curator (now designated as Petrologist) in-charge of the geological collection of the Asiatic Museum in Calcutta, except for a few days from April 20-27, 1927 when he was asked to report on the hill slopes around Naini Tal in Uttar Pradesh. Our knowledge of the Dethi's and other rock formations of Rajasthan is mainly based on the works of Coulson and others. It was conferred that Rajasthan underwent intense diastrophism in post-Delhi times where other regions were comparatively undisturbed. Coulson examined the basic rocks and their metamorphism which led him to conclude Sirohi and Ajabgarh series as contemporaneous lava flows. There is no detailed published account of his years of mapping in the North-West apart from summaries in the Director's Annual Reports, and some economic papers. In South Waziristan, field work was limited to areas around the camps and forts of the South Waziristan Scouts and pursued, under armed escorts of scouts and local levees, but tribal unrest finally compelled the cessation of his work in that region in 1937.

In 1931, India faced the world economic depression. The Geological Survey of India suffered from a drastic retrenchment, except for the Director (now Director-General) and another senior officer, all the elderly officers were retired and field work was curtailed. The geologists were then considered as costly cultural personnel, and even some ventured the opinion that the Geological Survey of India had outlived its useful existence. The posts of Superintendent (now Director) were reduced from six to three. Coulson was appointed as Assistant Director during 1932-33 and stationed in Calcutta. During this period he also acted as Palaeontologist of the Survey. He went on leave out of India for about 8½ months from October 1934 and returned in June 1935. He was posted as Curator and part-time Lecturer at the Presidency College but before long officiated in place of Dr A M Heron as

Superintending Geologist in charge of Southern India. During 1935-36, Coulson worked in North Western Province and South Waziristan, and was appointed as Superintending Geologist in April 1936 and detailed for work there, continuing the survey of North West Frontier Province. He also investigated the water supply problem in central parts of Baluchistan in January 1937. He visited the Makerwal colliery from February 4 to 6, 1937. In the course of his survey of Mardan district, he examined the marble and dolomite deposits of Ghundai Tarako forming the boundary between the Swalic tehsil of Mardan and the Buner track of Swat. The deposits are perhaps the largest and finest in North West Frontier Province. He reported on frequent occurrences of copper ore in South Waziristan. Before closing his field season in August 1937, he examined the Malakan Hydel Project.

In 1938 Coulson received unofficially a Rockfeller scholarship for study tour in Britain, at the Sorbonne in Paris, at Bonn in Germany at Basle in Switzerland. Mrs Coulson as well as his mother-in-law accompanied him. During this period he obtained his MSc and later DSc from the Melbourne University. He proceeded on leave out of India from the field on 14 April 1938 and returned to duty on the 7 November, 1938. On return from leave, he left for field work in North-West Frontier Province on 5 December 1938.

During 1939-40 Coulson was placed in-charge of the Assam party. He made some geological survey of North Cachar, and Mikir Hills and investigated the water supply in Darrang district in company of P N Mukherjee. He reported on coal in the Cherra sandstone in North Cachar, water supply of Lumding in Nowgon district. Coulson proceeded on leave out of India preparatory to retirement on October 17, 1940.

His best-known works on economic geology are his *Memoirs* on Barytes and Asbestos deposits in the ceded districts of Madras, the sequal to a season in South India during 1931-32 and on the mineral resources of North West Frontier province (1940-41). But his interest in minerals ranged over a wide field : asbestos coal chromite, dolomite, gold, limestone, lollingite, oil shales, pyrite, zinc, spinel etc.

Coulson also attended to economic enquiries. In 1922-23, he traversed some coalfields of Madhya Pradesh as geologist accompanying the Central Coalfields Railway survey party but without finding in superior quality coal outcrop. He collected tuffaceous rhyolites from near Injan Dheri, Mardan District, Pakistan, which on assay yielded 0.3 to 4·3 dwt. of gold per ton. He reported on limestones, dolomites and marbles of North West Frontier Province and found some of them are of excellent quality. In 1932, he carried out systematic investigations of barytes in Cuddapah, Anantpur and Kurnool districts in Andhra Pradesh and recorded 55 new important deposits. Most of these deposits are found as either replacements of fissure veins in the Vempalle lime-stones, or in intrusive dolerite and basalt sills. He reported on the superior quality in the Cuddapah district.

While carrying on investigation of barytes in Kurnool district, Coulson found previously unrecorded ancient diamond working in the Dhone taluk. He believed that ancient sills were the original home of the diamond.

It is his opinion that all the supplies of good water from the Calcutta tubewells are derived by percolation from the Ganga and Brahmputra rivers which lie more than 100 miles to the north; the rate of percolation being probably a mile or so annually. He was of the view that constant sinking of tubewells without some official control of their locations might eventually lead to the deterioration of the quality of water.

In Mardan and Peshawar districts of North West Frontier Province of Pakistan, Coulson recorded unusual case of water supply; here a barrier of impervious slates crossing the Indus gorge at Attock has restricted the drainage of the Kabul valley and caused equalisation of groundwater and possibly rendered it harder.

He submitted many unpublished reports on engineering geology, ranging from rail and road alignments, to hill stability and bridge and dam foundations. His investigations on the geology and underground water supply of Calcutta with special reference to tube wells and water supply of Darrang district, Assam and Meanwali district, Punjab are valuable.

The breadth of his interests is well illustrated by his publications on meteorite and on earthquakes. His Catalogue of Meteorites was the most complete descriptive catalogue of meteorite falls upto 1939, with special reference to Indian falls and finds and to speciments in the Indian Museum. He himself having described several meteorite falls in Hyderabad (NAOKI) and Bengal (Patwar and Perpeti and one in sua). Coulson's interest in earthquakes originated with his paper on the North West Himalayan earthquake of February 1, 1929, and he estimated its depth of epicentre at about 25 miles north west of Abbotabad (Pakistan). He also gave an account of the Hindu Kush earthquake of November 14, 1937 and of Shocks in Burma during 1929-30 and earthquake of the Great Pamir in 1940-41.

TEACHING ASSIGNMENT

In 1927-29 and 1935 he served as a part-time Lecturer in Geology at the Presidency College, Calcutta. He was the President, Geological Institute, Presidency College (1935-38) and played a leading role in inaugurating the first issue of the Institute's organ *Bhuvidya* in 1937.

HONOURS

Coulson was elected a Fellow of the Geological Society of London and a Foundation Fellow of the National Institute of Sciences of India (now INSA). He was for sometime Honorary Joint Secretary and Member of Council of Mining, Geological and Metallurgical Institute of India.

FAMILY

In 1925, Coulson married Dr Violet Gertrude Eddy. There was one child, Rosemary Lennox by the marriage. The husband and wife had known each other many years prior to marriage and spent many happy days on geological excursions, with the consent of Professor Skeath and Professor Sumess. Mrs Coulson was allowed to go in for playing tennis, boating and swimming. In India, they spent their time camping together on geological surveys, and in Calcutta their recreation was tennis, golf, swimming and rowing. Holidays were spent in Australia or Britain or locally at Puri, Darjeeling, Mount Abu or in Kashmir.

RETURN TO AUSTRALIA

Towards the end of 1940, the onset of a serious illness was suspected, and he was advised to travel immediately by air to Australia. He never returned to India and retired from the Geological Survey of India on invalid pension in 1942.

In the early stages of his illness, his past experience and fine analytical faculties were called upon the Australian military forces during the later part of World War II. As a Major in the Australian Engineers he advised on ground water supply for the military forces in various parts of Australia and New Guinea.

In 1946, Coulson was demobilised and lived privately at Kew in Melbourne for three years but his illness worsened and he spent his remaining years at Heidelberg Repatriation Hospital, Melbourne, and finally at Angac Hostel for TPI. The effects of his illness became increasingly severe and he died in 1955, leaving behind his wife, Dr Violet Gertrude Eddy, and a married daughter Rosemary.

EPILOGUE

Dr Coulson was a man of intense study and wealth of scientific interest. A born geologist, he gave his best to India and is remembered for his likable good nature and friendly personality. He took keen interest to scientific affairs of India.

A K DEY
A K GHOSH

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S. Swaroop

SATYA SWAROOP

(1913-1962)

Elected Fellow 1956

EARLY LIFE AND EDUCATION

SATYA SWAROOP was born on February 20, 1913 at Gurukul Kangri near Hardwar in the district of Bijnor in Uttar Pradesh. His parents, the Uttam Chands, had only two sons, the other one being Satta Swaroop who was elder to Satya Swaroop.

Dr Satya Swaroop had a brilliant academic career. He studied at the DAV High School, Delhi during the period 1924 to 1927 and passed the Higher Secondary School Leaving Certificate Examination in the first class. He attended the St. Stephen's College of Delhi University during the period 1927 to 1933 and received his BA (Hons) degree in 1931 and MA degree in Mathematics in 1933, securing the first division.

In 1947, Satya Swaroop obtained the PhD degree of the Panjab University for his thesis "The Demographic Study of Small-Pox in the Punjab". In the same year he was awarded a fellowship of the Rockefeller Foundation for studies abroad and spent the academic year 1947-48 at the School of Hygiene and Public Health, Johns Hopkins University and secured the degree of Master of Public Health.

PROFESSIONAL CAREER

Dr Satya Swaroop joined the newly established All India Institute of Hygiene and Public Health, Calcutta as a Research Assistant in 1934 shortly after taking his MA degree. The interest that was created in him at that time in the fields of Vital Statistics and Epidemiology persisted throughout his life and made him an outstanding health statistician and demographer. He officiated as Assistant Professor of Vital Statistics and Epidemiology at The All-India Institute of Hygiene and Public Health during 1937-1939. In 1939, he became the Statistician to the Public Health Commissioner, Government of India and served in this capacity for about four years. Between 1943 and 1947, he served as Statistical Officer to the Punjab Public Health Department.

On his return to India after taking the MPH degree, Dr Swaroop had two brief periods of appointment in the country before he joined the staff of the World Health Organization. During 1948-1949, he continued to serve in the Punjab Health

Department. He served as Professor of Statistics at the All India Institute of Hygiene and Public Health, Calcutta during 1949-1950.

Dr Swaroop was appointed in the World Health Organization as Chief, Statistical Studies Section in 1950. The post was redesignated as Chief Statistician, Health Statistical Methodology in 1959. During his service with the World Health Organization, Dr Swaroop travelled extensively, advising governments on health statistics, lecturing in many different institutions and participating in many international conferences. In 1958, Dr Swaroop was Visiting Lecturer in Biostatistics at Johns Hopkins University.

Dr Swaroop was a Member of a number of national and international professional bodies concerned with statistics and public health. On January 1, 1956, he was made a Fellow of the National Institute of Sciences of India (now INSA). In 1959, he was elected a Member of the International Statistical Institute.

SCIENTIFIC ACTIVITIES

Dr Swaroop's research activities can be divided into three phases and termed 'supportive', 'health-oriented' and 'promotional' in keeping with his scientific contributions during these three periods. 'Supportive' contributions were made shortly after he finished his formal education and joined the All-India Institute of Hygiene and Public Health as a Research Assistant. At that time young Swaroop did not have any training in statistical science which, in any case, was still in its infancy; nor did he have any research experience to help him. Further he also had no background in medicine or public health despite his holding a position at the Hygiene and Public Health Institute. His association with Professor R B Lal and Assistant Professor K C K E Raja, in the Section of Vital Statistics and Epidemiology at the Institute helped Swaroop to get acquainted with some medical and public health problems in which the section was then interested. Swaroop had not only to get a feel of these problems and had to learn on his own the methods of statistical analysis.

The second phase of "health-oriented" contributions relate to his activities after he had received training at the Johns Hopkins University and more particularly after he became a staff member of the World Health Organization. His interests began to broaden and cover such topics as the use of statistical methodology in the control of specific diseases (malaria is one example), the development of health indices and the study of the relationships between mortality in specific age groups and the general death rate as a guide to improvement in health conditions. In the third phase, Dr Swaroop used the experience gained over the years in promoting the collection and analysis of health statistics.

Dr Swaroop's contributions in the 'Supportive' phase of his research activities

In the 'supportive' phase of his activities, Dr Swaroop (a) collaborated in studies on the endemicity and epidemicity of cholera in Bengal; (b) applied the procedures developed by Alfred Lotka to forecasting the size and structure of India's population; and in addition, studied the effect of a decrease in infant mortality on the future population of India; (c) worked out the numerical significant limit of a test to evaluate the difference between proportions based on a pair of small samples using a formula already available and (d) provided the estimates of number of organisms and their standard errors for observed configurations when routine 'dilution tests' are used to study the quality of water samples.

(a) *Studies on the endemicity and epidemicity of cholera in Bengal*

Various aspects of the epidemiology of cholera were being researched by different institutions in India at that time and the All-India Institute of Hygiene had taken up a study to assist in the identification of one or more foci of cholera prevalence in West Bengal where the disease was endemic. The routine official statistics, albeit incomplete and inaccurate, were used for the purpose and Dr Swaroop collaborated with his two senior medical research workers and Mr K C Basak in developing new techniques which could lead to the identification of such foci.

Epidemic diseases exhibit a variability in incidence during the different parts of a year and also from year to year. The criteria to be taken into account in describing the course of an epidemic disease are, therefore, (a) the intensity of incidence, (b) the distribution of its prevalence within the year, and (c) its variation from year to year.

In comparing one place with another, usually these three characteristics are compared separately. There are several disadvantages of this method which rests purely on mere inspection of data. In order to overcome these disadvantages, it was reattempted to (a) provide a method by which one can numerically assess the various characteristics independently of one another, (b) estimate the errors of these measures due to random variation, and c) provide tests by which to compare places after taking all the three factors into consideration. The methodology applied here was based on the concept of analysis of variance.

The application of the method to the data relating to a place consists essentially in splitting the total variability of incidence round the mean into the following parts:

(a) Seasonal variability or between months, (b) Cyclical variability or between years and (c) Residual variability.

In the first step, the method of bivariate analysis of variance is applied to the data of a number of centres (*thanas*) and the seasonal and yearly variations are tested against the residual by the Z test, with a view to combining those *thanas* which were contiguous and which exhibited similarity. Secondly, the groups of *thanas* which appeared to be similar on inspection of the results of bivariate analysis, were combined and trivariate analysis was carried out, the variability being split up into the following :— *Main Effects* : (a) between means of *thanas*; (b) between means of months and (c) between means of years. *Interaction* : (d) between *thana* and month; (e) between *thana* and year; (f) between month and year and (g) residual.

The authors applied the trivariate analysis of variance on the cholera mortality rates per 10,000 population of a group of three *thanas* in Backerjung district of Bengal. Similar analyses were carried out on several groups of centres (*thanas*) and it was found that the tests were too rigorous to admit of even three contiguous centres being combined. To avoid these complications, the procedure followed was to work out the percentage contributions to total variance of each of the sources of variation. If the contribution from any one of the sources (a), (d) and (e) was more than 5 per cent of the total variance then the places were considered significantly different from each other. The authors further stated that though the method lacks theoretical justification, it provided an objective test for establishing heterogeneity in epidemiological investigations.

(b) *Statistical inquiry in epidemiology of cholera in Bengal*

The work relating to this inquiry was published in the Indian Journal of Medical Research in three parts. The extent of similarity of cholera incidence in the different parts of Bengal was discussed in this paper. Considerable heterogeneity was found among the districts as well as among the *thanas* constituting individual districts. The authors further pointed out that a distribution of the *thanas* into homogeneous cholera districts was the essential pre-requisite for a systematic study of the epidemiology of cholera and for formulation of suitable methods of forecast.

On the basis of the findings of their previous study, Dr Swaroop and coworkers felt that it was necessary to devise methods to secure adequate description of the characteristics of each *thana* in numerical terms for a systematic study of the epidemiology of cholera. Thus, they made an attempt to determine the extent of similarity with respect to epidemiological characteristics in contiguous *thanas*. Taking *thana* as a unit, the total variability of cholera incidence was split into three variables, viz., seasonal, yearly and residual by the method of analysis of variance.

Contiguous *thanas* showing similarity with respect to mean cholera incidence and type of seasonal curve were combined and the districts so obtained were tested for homogeneity by the analysis of variance technique. Those satisfying tests of homogeneity were constituted into cholera districts.

The sizes of the homogeneous cholera districts varied from individual *thanas* to a combination of 20 such centres. The boundaries of the cholera districts and the administrative districts did not correspond. Accordingly, it was concluded that the redistribution of the area into homogeneous cholera districts provided a basis for the investigation of the underlying factors in the natural history of cholera.

An attempt was made to investigate the endemicity and epidemicity of the cholera homogeneous districts. A frequency distribution of varying intervals of absence of cholera was worked out for each *thana* individually and for the *thanas* constituting each homogeneous district collectively. Since the gross endemicity so determined is subject to variations due to differences in population, area and the number of *thanas* constituting the districts, the effect of these factors were eliminated by the method of partial regression. The net endemicity so determined has been used to classify the homogeneous districts into endemic and non-endemic. Using the yearly variance as a measure of epidemicity, the homogeneous districts have been divided into five arbitrary groups. Thus, the epidemic and endemic characters of various homogeneous cholera districts of south-west Bengal were defined.

(c) *Studies on India's population growth*

The applicability of the logistic law to Indian population (during the period 1872-1931) was studied by Dr Swaroop. The trend of birth and death rates as well as of age distribution were calculated on the basis of Lotka's deduction and it was shown that they gave fairly good fit to actual happening. It has further indicated that improvements in mortality conditions will lower the level of the birth rate trend and when the factors responsible for these improvements have ceased to operate, the birth and death rate curves will tend to approach each other.

On the assumption of a fixed life table, a constant birth rate may be considered a feature of the Indian population. If trends of birth rates are examined on the basis of fixed but different life tables, it is found that in each case the trend lines are almost linear but they are at different levels depending upon the mortality conditions expressed by the life tables on which they are based. The important point to note is that the better the mortality conditions the lower is the level of these trend lines. Trend of birth rates in India under such declining mortality will take a downward course depending upon the rate of improvement of mortality conditions.

Satya Swaroop's findings are not of any practical interest in today's context but it brings out one characteristic of Swaroop, viz., that he kept himself abreast of literature and to the extent possible attempted to apply new techniques to the practical problems on hand.

In British India, the trend of the infantile mortality rate had definitely been downwards during the period 1920-40. The probable effect of declining infantile mortality on the future growth of India's population during 1951-61 was estimated by Dr Swaroop. The estimates were made on the basis of available information relating to British India alone. However, he assumed that the British Indian rates may reasonably be applied to India as a whole. The author commented that the increase in population set out in this note by the middle of the Census Years 1931, 1941, 1951 and 1961 will give some idea of population growth for British India and Indian States. After a good deal of analysis and discussion, he concluded that the decline in infantile mortality during the period 1920-1940 would have added approximately eight hundred thousand persons to the population of India by the middle of 1931 and over 3 million by the middle of 1941. He further stated that if it is assumed that the decline in infantile mortality will continue at the same rate as in 1920-40, the population in the middle of 1951 and 1961 are likely to increase by about 7.0 million and 13.4 million respectively. On the other hand, if the infantile mortality rate continued to be 160 per 1,000 live births (the figures for 1941) the corresponding increases in population in the middle of 1951 and 1961 were likely to be 6.5 and 11.1 million respectively.

(d) *Significance of the difference between two proportions*

Dr Swaroop suggested a technique for providing necessary statistical tables for testing the significance of differences between proportions based on pairs of small samples which is specifically important in several fields of biological investigation. For instance, it is required to compare the therapeutic effect of two drugs by experiments on animals, the response noted being death or survival. If x_1 is the number of animals cured by the first drug out of a total of n_1 and x_2 the number of those cured by the second drug out of n_2, the problem is to examine the significance of the difference between the proportions p_1 given by x_1/n_1 and p_2 given by x_2/n_2. The author gave the exact probabilities for the different distributions of x_1 and x_2 assuming $n_1 = n_2 = n$ for the values $n = 5, 10, 15, 20, 30, 50$ using the formula developed by R A Fisher.

(e) *On the estimation of the number of organisms using the dilution method*

Attention was paid on the problem of estimation of the most probable number of organisms present in a water supply as tested by the inoculation of varying quantities in a liquid medium. A suitable method for the determination of the standard error attached to the probable number had been worked out and tables had been constructed which could be used to simplify the calculation for the determination of the most probable number and the standard error of this number. The relationship between the number of tubes used for any set of dilutions and the accuracy of the probable number is given. The tables for the probable numbers given by the Ministry of Health, England, have been reconstructed so as to given the value of the probable numbers correct to the nearest unit and their standard errors have also been calculated.

In the previous papers, formulae were developed for the purpose of determining the accuracy with which the most probable number of organisms in water samples may be estimated by the so called dilution tests. It is well known that modifications in carrying out dilution tests can be made by changing the number of tubes taken for each dilution or by choosing varying dilutions of the suspected water-supply. It was shown that the accuracy of estimation of the most probable number of organisms depends not only on the number or tubes used and/or on the dilutions chosen but also upon the number of organisms present in unit volume of the supply. Without the knowledge of the most probable number of organisms, which clearly is what the test is designed to estimate, it may appear *prima facie* impossible to lay down any general rules which should govern an analyst who is designing his tests. But, in absence of this knowledge it was suggested how the test could be usefully planned.

The two sets of dilutions which have been recommended for routine tests by the Ministry of Health, England, (1939) were :—

(1) The dilutions 1/2, 1/10, 1/100 with 1, 5 and 5 tubes for the respective dilutions,

or

(2) The dilutions 1/10, 1/100, 1/1,000 with 5 tubes chosen for each dilution.

The efficiency of these two sets of dilution was discussed and it was pointed out that, in those cases in which the contamination of the suspected supply is not very high, such as piped water supply, it would be advantageous to replace these two tests by taking a set of dilutions similar to those as in the case (1) above, but by choosing an equal number of tubes for each dilution. This modification shows greater efficiency in the estimation of the probable number of organisms over a range of values for which the test will usually have to be carried out. For instance, it can be shown that, when the number of organisms in 100 c.c. is one, the accuracy gained by taking 5 tubes of each of the dilutions 1/2, 1/10, and 1/100 is the same as will be obtained by taking 22 tubes of each of the dilutions 1/10, 1/100 and 1/1000 and that negligible gain in accuracy is produced by choosing 5, 25 and 25 tubes of the dilutions 1/2, 1/10 and 1/100 respectively. Again, if the number of organisms in the supply is 20 per 100 c.c. the effect of taking one tube of each of the dilutions 1/2, 1/10 and 1/100 is for all practical purposes equivalent to taking 1, 5 and 5 of the three dilutions 1/2, 1/10 and 1/100. In other words if the suggested modification was used we would require only 3 tubes instead of 11.

In view of the relative advantages of this modification over the two routine sets now commonly employed and the possibility of their replacement by the suggested modified test, tables were provided, for reading at a glance, the most probable number of organisms in 100 c.c. of the supply and the standard error of the most probable number when, for each of the dilutions 1/2, 1/10 and 1/100 the number of tubes chosen is either 2, 3, 5 or 10.

Halvorson and Ziegler attempted to build up a statistical technique for appraising the accuracy of the dilution method. They considered a simple case when only one dilution was chosen and came to the conclusion that the accuracy of estimation depends not only upon the number of tubes inoculated from the sample but also upon the bacterial density of the suspected supply. Dilution tests are, however, carried out by taking for each test a number of dilutions. In order to meet these cases Halvorson and Ziegler extended their analysis and came to the conclusion that 'when three effective dilutions are used to determine the bacterial population, the accuracy is independent of the number of organisms and depends only on the number of tubes used in each dilution'.

The problem was also studied by Swaroop. A general formula was given for calculating the standard error of the most probable number of organisms. While discussing the efficiency of the dilutions method, on the basis of this formula, it was stated that the accuracy of the dilution technique was dependent on all relevant factors, viz. (a) the number of tubes used for each dilution, (b) the bacterial density of the suspected supply and (c) the number and type of dilution used for the test. As the conclusion reached by Halvorson and Ziegler is at variance with the above finding, Dr Swaroop has made an attempt, to investigate the reasons for such anomalies.

Dr Swaroop's contributions in the 'Health-oriented' phase of his research activities

During this phase Dr Swaroop's research activities related to (a) studying death rates in specific age groups and (b) further developing his previous concepts on indices of epidemicity. He examined, with special reference to areas of high death rate, the influence of the various forces or factors that affect infant and childhood life, so that their understanding may lead to quicker and more effective attempts to improve health conditions in the early years of human life. Dr Swaroop categorised the data available on Infant Mortality Rate (IMR) of developed and underdeveloped areas, into four groups :

(1) Low : Infant mortality rate of 40 per 1,000 live births,

(2) Moderate : Infant mortality rate of between 40 and 80;

(3) High : Infant mortality rate between 80 and 120;

(4) Very high : Infant mortality rate of 120+.

It was found that high death rates were recorded both among child and adult population in those countries possessing high infant mortality Dr Swaroop commented "In areas of high death rate, averse mortality conditions in infancy and childhood are responsible for reducing the average length of life by as many as 10 to 15 years". Therefore, if health conditions in the earlier ages were to improve, a sizable relative increase in the adult and economically productive part of the population would ensue. The factors associated with environmental conditions and particularly domestic sanitation, make their effect more strongly felt on child life with increasing age, so that deaths in the second to twelfth months are largely attributed to preventable causes. Countries where adverse environmental conditions still play a major part in the mortality, show a high value of this percentage during this age period, examples being Egypt 81%, Mexico 66%, Chile and Peru 64% and India 55%. One important reason why the infant mortality rate is high over wide areas of the world is that a large variety of preventable diseases still remain uncontrolled.

Whereever a substantial reduction in infant or child mortality has been recorded it is attributable to an increasing degree of control over the prevailing diseases of the area concerned or improvement in environmental sanitation. Thus, in countries where malaria incidence was high, its control by DDT produced a striking reduction in infant and childhood death rates.

In 1954, the United Nations Committee of Experts on International Definition and Measurement of Standards and Levels of Living suggested that the measurement of levels of living using quantifiable or potentially quantifiable components should be given important consideration. An attempt is made to evolve a single, comprehensive numerical indicator to quantify the component "heatlth, including demographic conditions".

The use of an objective statistical technique as a guide in the selection of such an indicator is suggested. From the application of this technique, it is concluded that the percentage of deaths at the ages 50 years and over to total deaths (proportional mortality) affords a fairly suitable yard stick by which broad inter-country comparisons may be made. This indicator has the advantages of simplicity of calculation, comprehensiveness, availability of data, possibility of international comparability despite the varying quality of basic statistical information, sensitivity for the purpose of inter-country comparisons, and validity for studying levels and trends.

The statistics on mortality from accidents, with special reference to those relating to the age-group 1-19 years was discussed by Dr Swaroop. For a number of countries, figures are given for the proportional mortality from accidents (the number of accidental deaths expressed as a percentage of the number of deaths from all causes) and specific death rates from all causes of accidents and from various types of accidents. From these figures it appears that, in most countries, accidents are becoming relatively increasingly prominent as a cause of death in childhood primarily because of the conquest of other causes of death—such as infections and parasitic diseases, which formerly took a heavy toll of children and adolescents—but also to some extent because the death rate from motor-vehicle accidents is rising and cancelling out the reduction in the rate for other causes of accidental death. In the opinion of the authors, further epidemiological investigations into accidents causation are required for the purpose of devising quicker and more effective methods of accident prevention.

A protein malnutrition survey was carried out in ten areas of four States of South India among children under 5 years of age in families with a monthly income of less than Rs 100, estimated to constitute 85% of the population. The diets investigated consisted largely of cereals, with small quantities of pulses and green-vegetables; milk, meat and eggs were little eaten. The survey covered investigation of infant care, feeding and weaning practices, clinical examinations, anthropometric measurements, determination of haemoglobin and serum protein levels and analysis of hospital records.

Although infants were usually breastfed for a long time, the quantity of breast milk was found to be low after 6 months, at which time supplementary foods were introduced, but these were usually inadequate. Extreme growth retardation was seen after weaning. Diarrhoea was complained of in some 20% of children. Such deficiency signs as dyschromotrichia, hepatomegaly, moon face, angular stomatitis and xeropthalmia were frequently seen. Cases of Kwashiorkor and marasmus were observed in 1% and 1.7% respectively of children at home. These findings and others clearly show protein malnutrition to be a problem of very considerable magnitude in the poorer communities of South India. A comparison is made with the results of surveys conducted in Africa and Central America.

Considering the difficulties involved in defining the term "endemicity" and the non-availability of internationally accepted definition of the term, Dr Swaroop suggested some indices of endemicity, based on such data which are usually collected by national health administration (mortality and morbidity rates, spleen rates, case incidence in sea ports etc.). The term "endemic area" was defined, vaguely by an area in which fresh cases of the disease can arise without importation of infection from outside, without giving any methodological technique, whereby, uniformity can be attained in judging the endemic status of a disease or an area. The weakness of the concept-mentioned above as emphasized by Swaroop, was that it does not consider the size of the affected area which is necessary to construct a suitable index for the purpose of comparison. The author explained clearly, the drawbacks of the above-mentioned concept by some examples. Thus, he stressed on having not only an unambiguous definition but also a practicablemethod of assessing endemicity status by means of the resources normally available to a public health administrator.

Analysing critically the recommendations made by WHO expert groups and considering the problem of determining endemicity from the point of view of locating zones where administrative action needs to be concentrated, Swaroop suggested an index called 'endemicity index' for measuring the incidence of endemic disease.

The index of endemicity as suggested may be explained by an illustration of cholera in India. It may be mentioned that the 'districts' in the smallest administrative unit in India for which separate cholera statistics are available from published reports. There were some 200 districts for which such figures were available. An allowance for population size was made in the first place by calculating separate annual cholera mortality rates per 100,000 population for each district of India for the period 1901-45. Thus 45 separate annual cholera mortality rates were calculated. In those districts which were liable only to occasional outbreaks of the disease, even though in some years the mortality rate was very high, there were a number of inter-epidemic years during which no death from cholera was recorded. On the other hand, in certain districts where cholera tended to be present continuously, there was hardly a year when the cholera mortality rate was zero or negligible. From the point of view of endemicity, the question of the greatest interest was how a low level of cholera was attained. Thus, the years with relatively low mortality rates were studied. In the first instance, therefore, the 45 annual death-rates for each district were arranged in ascending order of magnitude. The 15 years with the lowest cholera mortality (one-third of the total number) could, thus, be separated from the rest of the series. For each district an average value of the 15 lowest rates was then calculated separately. The average figures of varying magnitude so obtained for various districts of India indicate numerically the relative levels of endemicity—the higher the average, the more endemic the district.

Some advantages of this index may be briefly summarised;

(a) It provides an objective method of approach, so that the relative level of endemicity can be numerically assessed and compared.

(b) It utilizes data which are usually available to national health administrations in respect of their administrative subdivisions, so that a country-wide search can be made for endemic foci.

(c) It provides an easy method for studying the geographical pattern of endemic foci.

(d) It is easy to calculate and interpret.

(e) It can be used for any series of figures expressed as rates reflecting incidence, prevalence or other manifestations of the disease.

But if infection persists in an area but does not affect man, this index will fail to indicate it. Moreover, this approach of endemicity does not solve the problem of how to demarcate an endemic area.

Dr Swaroop's contributions in the 'Promotional phase'

In the 'Promotional phase', Dr Swaroop sought to popularize the application of statistical methods in health work. One example was the publication (mimeographed) of a book in two parts entitled *Statistical Consideration and Methodology in Malaria Eradication,* World Health Organization, (1959). But what would be a lasting remembrance of Dr Swaroop's devotion to the improvement of health statistics is his *Introduction to Health Statistics* published in 1960 by E & S Livingstone Ltd. (Edinburgh and London), which is briefly described below.

The *Introduction to Health Statistics* reflects in more than one sense, the culmination of Dr Swaroop's rich experience extending over a quarter of a century in the study and practice of health statistics. Unfortunately Dr Swaroop met an untimely death within a couple of years after the publication of this book and, therefore, could not see the impact of his work. As Professor James M Mackintosh, Emeritus Professor of Public Health in the University of London, has stated succinctly in his Foreword to this book. "Dr Swaroop has himself visited many countries and given courses of instruction on health statistics. He has first hand knowledge of many of the challenging problems as they arise in health departments both small and great, as well as in the countries which are now only on the threshold of development. He himself comes originally from a rapidly expanding country and has an intimate feeling of the difficulties inherent in the various stages of progress. The book is based on personal experience and also on the wide opportunities of sifting and enlarging the experience of colleagues and students".

In his inimitable style, Dr Swaroop had combined both wit and a sense of purpose, in preparing this book. It is in a sense a manual aimed not only at arousing the interest of public health administrators to the importance of collecting public health statistics but guiding public health personnel, from the lowest to the highest echelons, to the procedures that can be used to improve the quality of public health statistics. As Dr Swaroop wrote in the preface to the book, "A vast organization is constantly at work and it is on the efficiency of the data collecting and producing machinery, if we may so term it, that the quality of the final product is judged. This gigantic machine has to be operated without friction on breakdown; its component parts have to be kept in good working order, faults anticipated, spare parts provided, raw material fed into the machine for processing, and the installation kept up to date. More than anything else, the machine requires lubrication and fuel to make it go".

PERSONAL QUALITIES

Dr Swaroop was short and heavily built and had a jovial personality. His loud laughter has echoed through many class rooms, lecture halls and corridors, including those of the Johns Hopkins School of Hygiene and Public Health. Dr Swaroop was a man of broad interests. He was keen on learning languages and could read and speak German fluently. He had a special interest in astrology and had collected a number of horoscopes of children with exact date and time of birth with a view to relate the horoscopic predictions with their survival to one year after birth.

Dr Swaroop had a gift for presentation and his lectures on health statistics were extremely popular with the students. While at Baltimore, preparing for the MPH degree, he took a Dale Carnegie Course in Public Speaking. His fellow students had a taste of his newly created abilities during a mock session in which Dr Swaroop had to play the part of health man presenting his budget for the consideration of the members of municipal council. Dr Swaroop's ability at public-speaking, along with his popularity were responsible for his being chosen as the main speaker at the end-of-the-year party given by his class of MPH students to the Faculty of the Johns Hopkins School of Public Health.

Dr Swaroop had a large family. He was the father of six children, four sons and two daughters. After his untimely death at the age of 48 (on February 1, 1962) while on an official mission for the World Health Organization, Mrs Swaroop and some of his children continued to stay on in Geneva. This is indeed because of the assistance and companionship which Dr Swaroop's family and children expected from the large circle of friends that Dr Swaroop, with his ability to cultivate friends whereever he happened to be, must have formed in Geneva.

Dr Swaroop was an extremely hard working man, working into late hours of the night, although a casual talk with him would not have revealed his serious pursuit of academic subjects.

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C CHANDRASEKARAN

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AMULYA CHANDRA UKIL

(1888–1970)

Elected Fellow 1935

EARLY LIFE AND EDUCATIONAL CAREER

AMULYA CHANDRA UKIL was born on November 14, 1888 at Bongaon in the District of Jessore (now in Bangladesh). His father, late Dr Nibaran Chandra Ukil was an allopathic practitioner in Bongaon. Amulya had his early school education in his native place, Bongaon, a Sub-Divisional town. He passed the Entrance Examination of the Calcutta University in the First Division from the Krishnanagar Collegiate School in 1906, and FA Examination in 1908 from the same College. Young Ukil then entered into the Calcutta Medical College and graduated in Medicine (MB) in 1914. In 1921, while serving as Professor of Bacteriology at the National Medical Institute, Calcutta he went to Europe to specialise in Bacteriology. There he came under the influence of Professor Calmette, the renowned tuberculosis specialist, to take up tuberculosis as a subject for specialization. Ukil later turned out to be the pioneer tuberculosis worker in India. He revisited Europe (Paris and Germany) as a Ghosh Travelling Fellow of the Calcutta University for two years and obtained the Degree of MSPE (Paris).

PROFESSIONAL CAREER AND NATIONAL CONTRIBUTION

After graduating in Medicine in 1914, he joined the Daulatpur Hindu Academy in the District of Khulna (now in Bangladesh) as Professor of Botany and Resident Medical Officer of the college including the attached Students' Hostel. But within a year i e, by 1916 he resigned from these assignments and started private practice in the Khulna District Town. During this time he involved himself with the then Revolutionary Party of Bengal. To avoid chasing by the police, he got into the Indian Medical Service as a war recruit and joined the training camp at Meerut. But he was arrested and interned for one year and eight months. He started professional practice at Calcutta after getting released in 1918. The same national spirit prompted him to join, in 1921 alongwith Dr Sundari Mohan Das, as a Founder Member of the Jatiya Ayurbijnan Vidyalaya. It was created as a National organization under the National Medical Council of Bengal (later renamed as the National Medical Institute). He served there as Professor of Bacteriology (1921-1931) and as Visiting Physician to the Chittaranjan Hospital attached to the National Medical Institute.

a. c. Ukil

In 1926, Dr Ukil was instrumental in the establishment of the Tuberculosis Association of Bengal with Dr B C Roy as its President. It was much later that the Tuberculosis Association of India was established in 1939 under the auspices of the King George V Thanks-giving Antituberculosis Fund. In the same year, the name of the Tuberculosis Association of Bengal was changed to Bengal Tuberculosis Association. Now there are 49 affiliated Chest Clinics in the State—27 around Calcutta and its suburbs and 22 in the districts. Over a lakh of patients receive treatment in these clinics of which at least 22.5 per cent are tuberculosis infected.

Beginning from 1927, Dr Ukil received a research grant for tuberculosis from the Indian Research Fund Association and was designated as the Director of Tuberculosis Research at Calcutta and continued to hold that post till 1943.

One of the memorable events in the history of medical profession in India was the establishment of the Indian Medical Association (1926) as an All India body by the cooperative and conjoint efforts of the then luminaries of the profession at Calcutta and other parts of India. Dr Ukil's role from the very beginning had been that of an active organizer and constructive cooperator as a member of the organizing committee along with the late Dr K S Roy.

On Ukil's return from Europe in 1931 he became the Honorary Visiting Physician for tuberculosis at the Out-patients' clinic of the Calcutta Medical College and later as the Physician-in-Charge of the Chest Department of the College Hospital. While performing his research activities under the IRFA (now called Indian Council of Medical Research) he showed outstanding abilities in organizing the chest department by his unceasing enterprise and application and succeeded in raising its standard as an all India centre for clinical teaching in tuberculosis.

In 1935, he started a National Research Laboratory for medical research in collaboration with Drs H Ghosh and J C Ray and a few other eminent medical scientists in Bengal. It was the first National Medical Research Laboratory to counter the hierarchial policy of the then British Government. The basic fund was provided by the income accrued from the simultaneous running of a clinical laboratory for examination of various types of clinical materials sent by the practising physicians in exchange of some fees. This laboratory received the blessing of men like Acharya P C Ray, Rabindranath Tagore, Pandit Madan Mohan Malaviya, Dr Nil Ratan Sircar, Shri A R Dalal, Dr C V Raman, Shri Gagan Bihari Mehta, and even of Mahatma Gandhi who also signed the first appeal for Indians.**

Following Independence, in 1947, he was appointed as the Principal of the Calcutta Medical College. The very next year he visited Europe and USA where he

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**On the attainment of freedom, this laboratory was recognized by Pandit Jawaharlal Nehru and Dr B C Roy. The Institute was renamed as the Indian Institute of Biochemistry and Experimental Medicine under the Directorship of Dr J C Ray. Finally the Institute was taken over by the Council of Scientific and Industrial Research and rebuilt at a cost of 8—10 crores of rupees in Jadavpur, Calcutta and was recognized as one of the National Institutes in India. It is now renamed as the Indian Institute of Experimental Biology. This Institute has the credit of making many original contributions to science which have received international and national recognition.

delivered a series of lectures on tuberculosis and also gained experience on the undergraduate medical education. On his return to India he voluntarily relinquished the post of the Principal of the Medical College on account of some difference with the authorities but continued to serve as the senior consulting physician of the Chest Department of the hospital till 1963. In 1949 he took over full time private practice and spent a good part of his time in public activities and in guiding several top-ranking scientific bodies in India as Member of the Executive Council of these societies.

As President of the Indian Medical Association, in 1955, Dr Ukil urged upon the Government to implement the Inquiry Committee's recommendations for centralising the administration for the control of pharmaceutical products and to tighten up the control on imports of items that were being manufactured in India. He also urged the members of the Indian Medical Association to take it as a matter of particular duty to use drugs manufactured in India, which satisfied internationally required standard of quality and efficacy.

Dr Ukil visited USSR in 1951 as a member of the scientific and cultural representation from India to gain personal knowledge about the medical and health service activities in that country. He revisited Europe twice—once in 1955 on the invitation of WHO and again on the invitation of the International Society of History of Science and delivered lectures in several universities in USA.

TEACHING AND RESEARCH ACTIVITIES

Dr Ukil started his life as a teacher of Botany in a Graduate College in rural setting. About six years later, he joined the Calcutta National Medical Institute as Professor of Bacteriology in 1921, and held that post till 1931. While working at the Pasteur Institute, Paris between 1921 and 1923 he discovered a new pathological anaerobic organism which was named after him as *Ukil's bacillus*. Upto the third decade of the present century our knowledge about the character of the tuberculosis organism prevalent in India and its epidemiology under Indian situation was inadequate. As Director of Tuberculosis Research under IRFA in Calcutta, Dr Ukil engaged himself to study all aspects of the infection namely, bacteriology, epidemiology, diagnosis, treatment, control and prevention and made many original observations and added substantially to our present-day knowledge about the disease. He published not less than 50 papers on the subject. However, his scientific thoughts were not confined to the study of tuberculosis alone but also to many other allied subjects such as nutritional status of the population of Bengal, public health policy in India, drug industry in India and social aspects of medicine and undergraduate teaching in medicine etc. In relation to the Bengal famine during the World War II, he discussed the Food Policy of the Government. As a Member of its Sanitary Board, he strongly advocated cultivation of soyabean in India. He delivered Basanta Memorial Lecture of the Calcutta University on the nutritionally balanced diet at a cheaper rate for the Bengali population to overcome mal- and under-nutrition. In the social aspect of medicine, he was the first person to train and appoint Tuberculosis Health Visitors in the tuberculosis clinics for follow up of the patients in their homes. This was later translated into practical use by the Government of West Bengal by organizing a training course on Medical Social Work at the Indian Institute of Social Welfare and Business Management, Calcutta under the Directorship of the present author. The trainees were absorbed in the regular government service to serve in hospitals, out-patients' clinics and also in the primary health centres.

As a visiting physician of the Chest Department of the Medical College, Ukil actively involved himself in teaching both the undergraduate and postgraduate medical students (TDD Course). Later, as Principal of the Medical College he tried to remodel the training with emphasis on social and community aspects.

POLITICAL AND SOCIAL ACTIVITIES

Dr Ukil's student life corresponded with the political upheaval in Bengal following the declaration of its partitioning by notification on October 26, 1905. The famous political leader Sir Surendranath Banerjee was arrested and fined. He was to be given an ovation at the Krishnanagar Town Hall. Amulya Chandra was then a student of the second year FA Class at the Krishnanagar College. He led a group of students to the Railway Station and pulled the carriage manually from the station to the town hall to the surprise of the leaders. He also showed evidence of leadership and social bent of mind by organizing a medical students' expedition for the first time to render help to the distressed and sick persons and families following the devastating Damodar River Flood in the Midnapore district of Bengal.

His political activities actually started at Daulatpur (Khulna) while working as a professor in the college and Medical Officer of the Khejurbagan hostel. He was proficient in swimming and riding and tried to train the boarders to learn these exercises to make them hardy and healthy. He noted that some boarders could not contribute their share of food expenditure and hence were given cheaper and poorer quality of diet. Since it was not desirable, he made the students agree to let every body to have the same food which could be provided by pooling the entire collection including his major contribution for sharing the same food with the boarders. Besides this arrangement he also arranged for board and lodging for many poor students. It is said that to save the lives of seriously ill patients he even crossed the river by swimming across the deadly Bhairab river. He also used to donate liberally to help the revolutionary movement out of his earnings in the earlier period of his life (ie., before settling down after marriage), particularly for those who dedicated their lives for the cause of Independence of the country. Even the Government of India in recognition of his/public service awarded him the 'Kaiser-I-Hind' Gold Medal in 1942.

While he was the Principal of Calcutta Medical College, he used to donate all fees received from examining the patients to the college Fund and utilised the ground floor of his residence within the college compound for holding night school for the children of the Class IV staff of the college hospitals. All his ideas about the social aspects of science will be found in his article on *Science and Society* published in the Journal of Science Club, in 1954. In fact his motto was to earn money for a moderate living and not to amass wealth by private practice.

ACHIEVEMENTS, AWARDS AND HONOURS

Dr Ukil was a true nationalist and his activities generally geared by his nationalistic fervour. His active association with at least three institutions bear testimony to this fact namely, (i) Jatiya Ayurbijnan Vidyalaya (later named as the Calcutta National Medical Institute), (ii) Tuberculosis Association of Bengal, and (iii) Indian Institute of Biochemistry and Experimental Medicine (now named as National Institute of Experimental Biology). In the development of these three national institutions his personal efforts and contributions cannot be minimised.

His scientific achievements were also highly significant and productive. He not only succeeded in creating a scientific atmosphere for the study of tuberculosis under the Indian situation but also created a band of workers who are greatly devoted to and very proficient in this work. In recognition of this contribution he was initially awarded Ghosh Travelling Fellowship for two years to carry out further studies on the subject in Europe. In 1935, he was awarded Coates 'Gold Medal for Medical Research by the Calcutta University and Barclay Memorial Medal of the Asiatic Society in 1951. He was also the first recipient of the Tuberculosis Association of India's Gold Medal. In his honour, the Bengal Tuberculosis Association has introduced 'Amulya Chandra Ukil Memorial Gold Medal', awarded yearly. He was elected Pesident of the following scientific organizations in succession : Medical and Veterinary Section of the Indian Science Congress Association in 1941; All India Tuberculosis Workers Conference in 1949, Indian Medical Association in 1955-56, President, Indian National Science Academy (1955-56), Indian Society of Chest Diseases in 1960, Asiatic Society in 1960-61, Medical College Reunion in 1961 and Indian Science News Association in 1961-62. He was also elected to deliver Basanta Memorial Lecture of the Calcutta University and Sir Jagadish Chandra Bose Memorial Lecture.

Of the other honours given by national and international bodies to following may be mentioned : He became Fellow of the Royal Society of Technical Medicine and Hygiene (London), Royal Sanitary Institute (London), the Honorary Member of the French Pathological Society, the Calcutta Branch of the Indian Medical Association, Emeritus Fellow of the Indian Academy of Medical Sciences and the American College of Chest Physicians, Honorary Fellow of the State Medical Faculty of West Bengal, Senator of the Calcutta University for a number of years, a Member of the Council of the International Union against Tuberculosis as a representative from India, the Dean of the Faculty of Medicine for sometime, Consulting Physician of Chest Diseases at the Institute of Post-graduate Medical Education and Research, Calcutta and Chairman of the First Medical and Publicity sub-Committee of the Bengal Tuberculosis Association in 1939 and Member of the Editorial Committee of the journal of the Association. On the social side, he was the Founder Chairman of the Calcutta Safety First Association and Joint General Secretary of the Bengal Bratachari Society, founded by the Late Gurusady Datta.

PUBLIC ACTIVITIES

Dr Ukil was associated with most of the important public activities in the city. He was a rotarian and became the District Governor of Rotary International in 1942-43 and Sheriff of Calcutta in 1955-56, a senior member of the Masonic Lodge and Founder Director of the Standard Pharmaceutical Works at Calcutta.

MEMBERSHIP OF SCIENTIFIC, RESEARCH AND EDUCATIONAL INSTTIUTIONS

Dr Ukil was Member/Fellow of the following organizations : Bengal Tuberculosis Association, Indian Medical Association, Indian Science Congress Association, Tuberculosis Association of India, National Academy of Medical Sciences (India), Council of International Union of against Tuberculosis, Indian Society for Chest Diseases, Asiatic Society, American College of Chest Physician, Corresponding Member of the French Pathological Society, State Medical Faculty of Bengal, Member of the Calcutta University Senate, Council of the Indian Institute of Science, Bangalore, Scientific Panel of the Indian National Planning Commission, and of several other local organizations. Interestingly, though a nationalist, he did not actively associate himself with any political organization in the country.

UKIL AS A PERSON

Dr Ukil possessed a rare quality of head and heart. He was strong in conviction, a true scientist in outlook and steady in action, and a socialist ready to help people in distress and a good organiser. He had a large circle of friends not only among his own profession but also among other professions and calling and was popular amongst all. He was actually a path finder to the management of tuberculosis problem in India and has left a school of notable and efficient workers in his own speciality. His public appeal for T B Seal Sale Campaign always yielded very good response from Bengal for raising funds that enabled the voluntary organization like the Bengal Tuberculosis Association to maintain a high standard of service in the country.

He was always sympathetic to youths who were trying to hold themselves and offered the unstinted assistance and encouragement for their rising and success. Another trait in his character was that inspite of his disciplined mind he had a lot of humour which he depicted during social functions and while in a group of friends.

Dr Ukil, a medical scientist and educationist, a patriot and socialist, a reformer and philanthropist, a leader of the profession and a distinguished son of India passed away on February 23, 1970 at the age of 82 years after a most eventful and successful career. His health deteriorated after 1963 which necessitated gradual restriction in his activities and remained actually bedridden for the last two years of his life. He left behind his wife, Srimati Shovana Devi, two sons and two daughters, but his second son died prematurely in 1977. India lost one of her illustrious sons and a very active and dynamic personality.

S C Seal

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JOHN ALEXANDER SINTON*

(1884-1956)

Foundation Fellow

FEW can have had so varied experiences in life and at the same time contributed so greatly to knowledge in a field of science as SINTON. Educated and taking his medical qualifications in Northern Ireland, and first in every examination he took in school or university, entering the Indian Medical Service, again the first on his batch, Sinton was to see active service in both world wars. In the first, as medical officer to an Indian cavalry regiment on active service in the Mesopotamian Expeditionary Force, he received the award of the Victoria Cross for conspicuous bravery and devotion to duty during an action at Sheik Sa'ad in 1916, thus having the unique distinction of being the only bearer of this honour to be also a Fellow of the Royal Society. Later in the Medical Research Department of the Indian Medical Service he was appointed the first Director of the Malaria Survey of India (now the Malaria Institute of India) an institution that under Sinton's direction and that of those following him was to become one of the chief centres of malaria research in the world. Then after retirement, but being still on the reserve of officers of the Service, he was in the second world war again recalled to military service and as Consultant Malariologist in several campaigns again saw active service in many countries, travelling extensively in India, the Middle East and Africa and later, as Adviser on Malaria to the War Office, again to travel and advise on measures against malaria, visiting Australia, New Guinea, the Solomon Islands and other areas. Finally retiring to his native Ulster at the age of 60 he took an active part in academic and public affairs and besides other activities was Pro-Chancellor of his University and in 1953 High Sheriff of Co. Tyrone.

It was to research, however, that Sinton's inclinations impelled him and throuhout his career he never ceased to make contributions to medical science, publishing some 200 scientific papers, most of them dealing with malaria, but including a series of some 40 papers on the systematics and structure of sandflies, a subject that seemed to have a fascination for Sinton from the time of his early studies when he worked with Professor Newstead at Liverpool on these flies, later shown to be vectors of oriental sore and kala azar. Only a few days before his death Sinton learnt that he had been awarded the Manson Medal, the highest honour given by the Royal Society of Tropical Medicine and Hygiene awarded triennially to the living author of such original work in tropical medicine or tropical hygiene as the Society thought worthy of the honour.

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PARENTAGE AND EARLY LIFE

John Alexander Sinton was born on 2 December 1884 at Victoria, British Columbia, the third of seven children of Walker Lyon Sinton and Isabella Mary Sinton (*née* Pringle), the sequence of births being a son, a daughter, a son and four daughters.

His father's people, the Sintons, were of original lowland Scottish origin, settled in Co. Armagh, North Ireland, for more than 250 years, during which time most of them belonged to the Society of Friends. They were mainly engaged in the linen industry and agriculture, but many emigrated to the United States. A cousin of Sinton's grandfather married Charles Taft, a brother of President Taft. Sinton's paternal grandmother (Hemmington) came from Chatteris, Cambridgeshire and also belonged to the Society of Friends.

The Pringles were also of lowland Scottish origin settled in Co. Tyrone, Monaghan, for about 250 years. They were mainly of professional and agricultural occupation. Two of Sinton's uncles on his mother's side were doctors and his mother's cousins included: (1) the late Professor H Pringle of Trinity College, Dublin; (2) James Pringle, KC, formely M P for Tyrone and Fermanagh; (3) Robert Pringle, barrister, Dublin; (4) Seton Pringle, formerly President of the Royal College of Surgeons of Ireland; (5) JC Parke, solicitor and Davis Cup tennis player, International rugby player and International golf player; (6) several solicitors. Sinton's maternal grandmother (Mackie) came from Nairn, Scotland, of a family mainly of professional and agricultural occupation. Both the Pringles and the Mackies were Presbyterians. Sinton's brother, the eldest of the family, was Director of James Mackie and Sons, Belfast, manufacturers of textile machinery, when he died aged 38.

The family came to Ulster in 1890, when Sinton would be about six years old. They were never in affluent circumstances and it was to his mother's influence, her hard work and unsparing devotion to educate and bring up her children in their proper sphere of life that Sinton ascribed any success her children may have had. She was widely read and a great lover of poetry.

SCHOOLING AND MEDICAL EDUCATION

Sinton's primary schooling was at the Nicholson Memorial School, Lisburn, Co. Antrim, where he was from the age of nine to fifteen. His secondary schooling was at the Royal Belfast Academical Institution (1899–1902) from which he matriculated in the Royal College of Ireland and entered the Art's School of Queen's College, Belfast. A year later he passed the First Arts Examination of the Royal University of Ireland and entered the Medical School of Queen's College. Here success followed success in prizes and honours in almost every subject or examination he undertook. He was prize-man in botany, physics, zoology and chemistry, with a special prize in the scholarship examination and took First Class Honours in Botany and Physics with 2nd Class Exhibition at the First Professional Examination. In his second year he was prizeman in a number of subjects, passing his Second Professional examination with Upper Pass and recommendation to proceed to honours. In his third year, he was again prizeman in anatomy, physiology, materia medica and other subjects, passing his Third Professional with Upper Pass and recommendation to proceed to honours. In 1907, as fifth year scholar, he was prizeman in surgery and midwifery and Gold Medallist in children's diseases. When graduating MB, BCh, BAO of the Royal University of Ireland, he took First Class Honours in Medicine, Second Class Honours (first place) with Exhibition in Surgery and First Class Honours with Exhibition in Midwifery and Gynaecology. After graduation he was House Surgeon and House Physician at the Royal Victoria Hospital, Belfast, and afterwards Riddell Demonstrator in Pathology at Queen's University. At this time he was also Hon. Pathologist to the Benn Ulster Eye, Throat and Ear Hospital and Clinical Pathologist to the Mater Infirmorum Hospital, Belfast.

Whilst at Queen's University Sinton took the DPH, Belfast (1910) (first place and special prize) and the DPH Cambridge (1910). After a course in tropical medicine at Liverpool he took the DTM, Liverpool (1911), again taking first place. From February to August 1912, Sinton was Research Scholar, under a post-graduate exhibition of Queen's University, at the Liverpool School of Tropical Medicine, where he became acquainted with Sir Ronald Ross and Professor JWW Stephens. In August 1911 Sinton joined the Indian Medical Service (taking first place in the entrance examination), but before proceeding to India was seconded for a year as research exhibitioner under a post-graduate exhibition of Queen's University, during which he studied protozoology at the Liverpool School of Tropical Medicine.

THE INDIAN MEDICAL SERVICE

The Indian Medical Service offered many attractions to those young medicals just passed through the schools and desiring an active life abroad, since, besides suitable salary and pension, there was a wide field of choice in different Government appointments, such as civil surgeoncies, specialist appointments with private practice, professorships in colleges or institutions, research appointments and other openings. The Service was, however, primarily a military one and on joining, an officer, until seconded to 'Civil', served in some military capacity, very commonly as Medical Officer to an Indian Regiment. Usually this period of military service lasted for a few years only, unless as some preferred to do they elected to remain in 'Military'. It was the experience of most young officers to spend these few years under peace conditions, living more or less the usual life of the European in India. This, however, was not to be Sinton's experience, for before the expiry of his period of military service there occurred the first world war so that he had many years of active service and it was not until the end of the war, actually 1921, that Sinton left 'Military' for 'Civil'.

MILITARY SERVICE

Sinton's first appointment was as regimental medical officer to the 31st Duke of Connaught's Own Lancers stationed at Kohat in the North West Frontier Province. He was also in charge of the Brigade Laboratory and at this time published several papers. One recorded the results of a study of Roger's method of treatment of cholera by hypertonic saline as seen in the treatment of 69 cases under his care. He also, in collaboration with his assistant, contributed a paper on eosinophilia in helminthiasis, giving a careful record of results in 150 cases including infections with *Anchylostoma duodenale*, *Ascaris lumbricoides*, *Trichuris trichiura* and *Oxyuris vermicularia*. On the outbreak of the Great War 1914-18 and after being RMO and SMO Moveable Column, Kurram Valley, in the N.W. Frontier, with the rank of Captain, he was posted to the Indian Expeditionary Force D (Mesopotamia) as RMO 37th Dogras and other units. It was in an engagement at Sheik Sa'ad at the time of the attempt to relieve Kut in 1916 that Sinton gained the great honour and distinction of being awarded the Victoria Cross.

The citation records that although shot through both arms and through the side he refused to go to hospital and remained as long as daylight lasted, attending to his duties under very heavy fire. The citation also notes that in three previous actions he had displayed great bravery. In the same campaign he was mentioned in dispatches on four occasions and received, from the Russians, the Russian Order of St George.

On return to duty Sinton, still in 'Military', was on active service in a number of theatres of war until 1920. He was for a time Sanitary Officer with the rank of acting Major in the Mahsud Operations on the N.W. Frontier, later in the East African F Force (Tanganyika) and then with the East Persian Cordon Field Force commanding a Cavalry Field Ambulance and Agency Surgeon, Khorassan. From August 1918 to April 1919 he was in the Turkestan Military Mission as SMO and commanding a Cavalry Field Ambulance with rank of Lieut-Colonel. In 1919, for a year he was DADMS (San.) successively in the Afghanistan Campaign 1919, the Mahsud Campaign 1919-20 and the Waziristan Campaign 1920. Many times Sinton was mentioned in dispatches and received many awards and medals. He was also awarded the O.B.E.

Mention has been made that the Indian Medical Service was primarily a military service and even though an officer had been seconded to 'Civil' he was still liable to recall in case of war. On the outbreak of the second world war Sinton, being still on the reserve of Officers, though then retired, was recalled to duty, but in April 1940, having reached the age limit was placed on the retired list and returned home, joining the Home Guard as a private. From June to November 1940 he was, however, re-engaged by the Royal Army Medical Corps as Consultant Malariologist to the East African Force and from April 1941 to April 1943 was employed by the Government as Consulting Malariologist to the Middle East Force, travelling in this capacity in many countries in the Middle East as well as in 1942 being on a tour to report on health conditions on the projected air routes for troops across Africa, visiting Soudan, French Equatorial Africa, Nigeria, the Gold Coast, the French Cameroons and the Belgian Congo. From March to July 1945 Sinton was on an inspecting and advisory tour for the Army to see malaria conditions in Assam, Burmah and Ceylon and on to Australia, New Guinea, the Solomon Islands and the Moluccas. When he finally retired at the age of 60 Sinton had served over 30 years, of which more than a third was spent on active service.

To return, however, to the termination of the first world war and Sinton's subsequent life in India whilst in civil employ. After a period of leave home, during which he worked under Professor Newstead studying sandflies of the genus *Phlebotomus* and under Professor J G Thomson on protozoological studies, Sinton returned in 1921 to India and was taken on the cadre of the Medical Research Department. For some years he was in charge of the Quinine and Malaria Enquiry under the Indian Research Fund Association and then in 1927 appointed the first Director of the Malaria Survey of India, in which appointment he remained until his retirement in 1936.

At this stage it seems desirable to explain briefly the nature of the appointments referred to and to give a brief description of the organization for research upon and control of malaria in India during Sinton's time, an organization in the growth of which Sinton played an outstanding part. This can best be done by giving a short account of the Malaria Survey of India and the steps that led to its coming into being.

THE MALARIA SURVEY OF INDIA

The Medical Research Department of the Indian Medical Service was constituted under the administration of Col. J T W Leslie IMS, Public Health Commissioner with the Government of India in 1904. It consisted of a sanctioned cadre of officers filling appointments in the Central and Provincial Government Laboratories and other Government sanctioned permanent posts. As time went on, increasing demand for additional researches and enquiries resulted in special grants for these being made by the Government. This eventually became the function of the Indian Research Fund Association, a body established in 1910 which received a special grant from the Government but was largely independent, in this much resembling (and antedating) the Medical Research Council in Great Britain. This Association financed such enquiries and other activities as were approved and sanctioned by its Governing Body. A further important development was the institution some years later of the Indian Medical Research Workers Conference, which was held annually at Calcutta, Delhi or other such location as might be decided upon and was attended by delegates from all parts of India. At such meetings, as a result of discussion, proposals for researches or enquiries were made that were usually accepted by the Indian Research Fund Governing Body and implemented. At the Meeting of 1925 sanction was obtained, as a result of proposals put forward, for a malaria, organization for India to be known as the Malaria Survey of India, the functions of which were briefly to be as follows :

(1) To be fully informed on all malaria problems. To advise the Government on all issues relative to malaria in India.

(2) To initiate enquiries and investigations on malaria.

(3) To undertake systematic research in due course into basic facts underlying malaria transmission, prevalence and prevention.

(4) To carry out epidemiological surveys and mapping.

(5) To advise upon and assist in carrying out antimalarial measures; to study these scientifically and to judge of and elucidate the results.

(6) To undertake clinical work on malaria including treatment.

(7) To assist affiliated researches.

(8) To teach and train officers and others in practical malaria work.

(9) To publish scientific, results, useful guides and bulletins.

Such an organization did not start entirely *de novo*. As early as 1916 an organization for India had been put forward and implemented following the Imperial Malaria Conference held at Simla in that year. Under this there was formed a Central Malaria Committee and a Provincial Malaria Committee and a Provincial Malaria Committee for each of the eight Provinces of India. Under the Central Committee there was established a Central Malaria Bureau at Kasauli where collections were started, a reference library begun and a malaria journal, *Paludism*, instituted. Under the Central Committee were also held classes of instruction in malaria field work and survey. Under the Provincial organizations malaria units under the direction of senior malaria officers were set up. As a result of this organization for the first time knowledge was gained regarding the local conditions relating to malaria throughout the greater part of India. The Malaria Map of India (1926) published under the names of the present writer and Sinton was almost wholly based on such work. The recall of almost all officers connected with the organization during the first world war led, however, to the virtual closing down of all such activities.

At the time of Sinton's return to India following the war the Central Malaria Bureau had been re-established at Kasauli and there were a certain number of enquiries and researches in progress. One of these was the Quinine and Malaria Enquiry financed by the Indian Research Fund under Sinton. There was also an important enquiry known as the Malaria in Sind Enquiry in which the conditions present in a new large irrigation project were being closely watched with a view to such measures being undertaken as would prevent the usual increased malarial incidence that followed upon such large-scale irrigation. There were other investigations in progress about this time, including one into the reason for a high malaria incidence at Karnal and measures to control this.

Under Sinton's direction these various activities were brought together under the new organization. The headquarters of the organization was fixed at Kasauli, incorporating the Central Malaria Bureau and its activities. A permanent field station and laboratory was established on the plains within easy access from Kasauli at Karnal, where a building, a large unoccupied hospital belonging to a Mission, was acquired, admirably adapted for the purpose with museum, lecture hall and ample accommodation for laboratory work. Here and at Saharanpur the malaria field classes were re-started and held annually. Besides temporary workers engaged in special enquiries a considerable staff was on the permanent cadre including an entomologist, a chemist and an engineer, with the necessary laboratory assistants, collectors and other personnel.

In December 1937 at the Research Workers' Meeting at Delhi the Government of India decided to take over the Survey as regards its public health and advisory functions and the whole organization, now named the Malaria Institute of India, was transferred to its present site at Delhi, by now the Imperial Capital of India. This, however, was after Sinton's time. But the paper 'Man-made malaria' made a deep impression on the Conference and undoubtedly had a considerable effect in the decision of Government to afford to the organization the status it now holds.

As Director of the Malaria Survey of India Sinton was *ex officio* a member of the Scientific Advisory Board of the Indian Research Fund Association under which the scheme was then financed and later a member of the Governing Body. He was also a member of the Malaria Commission of the League of Nations and Co-ordinating Officer for India in this body. In 1929 the Malaria Survey issued the first number of its journal, *The Records of the Malaria Survey of India*, now the *Indian Journal of Malariology*. During Sinton's time as Director there were published in the *Records* 195 papers, including 61 giving the result of malaria surveys or local enquiries into malaria, 75 relating to systematic and bionomical studies on *Anopheles*, including control measures, and 46 on treatment, parasitology or other studies on malaria. Other papers were published in the *Indian Journal of Medical Research* or in other journals. During the same period there were published two volumes of the *Fauna of British India* dealing respectively with the anopheline and culicine mosquitoes of India.

LIFE AND WORK IN INDIA

Sinton Published some 200 scientific papers, some in collaboration with others, but mainly in his own name. For the greater part these deal with various aspects of malaria : clinical studies; studies of the malaria parasites; researches on treatment and the evaluation of the new antimalarial drugs; immunology of malaria, especially as studied experimentally in monkey malaria; laboratory techniques; and other studies in relation to this disease. A certain number of these communications, however, relate to other subjects among which Sinton's contributions to the systematics and structure of sandflies of the genus *Phlebotomus* are particularly outstanding.

Some of this large volume of work was carried out in India, some when on leave or after retirement at home. Much of Sinton's earlier work on treatment was done at Kasauli where a Treatment Centre had been established at the Cantonment Hospital for the treatment of cases of malaria among British troops from all parts of India.

Kasauli is a hill station on the first ridge of the Himalaya foothills at which is situated the Government of India Central Research Institute and the Pasteur Institute of India for the treatment and study of rabies. It was a station for which there was easy access to Simla, then the summer headquarters of the Government, as also to Delhi, the winter headquarters, and indeed to the Punjab and India generally. It was here that Sinton for many years had his headquarters and where much of his work was done and where he had many facilities and opportunities of collaboration with his colleagues working at the above laboratories and hospital.

It was at Kasauli that Sinton met and married on 19 September 1923 Eadith Seymour Steuart Martin, daughter of Edwin Steuart Martin and Ada May Martin (*née* Martin), and where their daughter Eleanor Isabel Mary Sinton was born on 9 December 1924.

Later as Director of the Malaria Survey Sinton spent much time in the Field Station laboratories at Karnal and in visiting other places in India. When first appointed Director he made a three months' tour, visiting all centres where records of work on malaria in India were likely to have been kept in preparation of his 'Bibliography of malaria in India', published in the first number of the *Records*. It was as a result of this three months' tour that Sinton re-published in the following number of the *Records* the classical paper by Dempster (1847) on an enquiry into malaria in a canal area north of Delhi in which for the first time use was made of the spleen rate in mapping and measuring the intensity of malaria.

Many of Sinton's later observations, especially those on *Plasmodium ovale* and the newer antimalarial compounds were, however, made in England working as Manson Fellow of the London School of Hygiene and Tropical Medicine and at the Ministry of Health Malaria Laboratory at Horton, where unique conditions for such researches existed.

RESEARCHERS ON THE MALARIA PARASITE

Sinton's work was notable for the many contributions he made to different techniques connected with the study of the malaria parasite, improved methods of preparing and using thick films and interpreting appearances seen in these and especially in the enumeration of parasites and their identification. He was one of the first to repeat Bass's method of culturing the parasite and his technique for the fowl-blood method of enumerating parasites has been widely employed in studying the course of infections and in determining the parasite values in endemic malaria. In collaboration with Ghosh (1934) Sinton made important observations on malarial pigment, investigating the action of solvents and of oxidizing and reducing agents upon its optical properties and crystallization. He was especially interested in the changes produced by different parasites on the red cell and only a few months before his death he contributed a paper to the Jubilee number of the *Indian Journal of Malariology* discussing points that were still unsettled in our knowledge of the malaria parasite. In collaboration with Hutton and Shute he published a series of papers on *Plasmodium ovale* making a very thorough study of this parasite. His paper in collaboration with the present writer (1928) on the correct name of the malignant tertian parasite by pointing out the confusion that existed in the nomenclature was largely responsible for the taking up of this subject by Mr Francis Hemming, Secretary of the International Commission on Zoological Nomenclature, and the subsequent establishment of the names now in common use through an official opinion by that body, thus ending the confusion that had resulted from unsatisfactory attempts to use names which different authors thought to be correct.

RESEARCHES ON MALARIAL TREATMENT

In his earlier work on treatment of malaria quinine was still almost the only drug available for this purpose and Sinton added much to the knowledge of how it should best be used. In particular he pointed out the value of using this drug in combination with alkali with a view to increasing the alkalinity of the blood. He determined by controlled experiment the effect of different dosage and duration of treatment upon the relapse rate and gave many practical points to help those responsible for its use, including a simple method of testing the amount of quinine in medicinal solutions. As other potentially effective compounds became available Sinton early undertook controlled research on their role in treatment and was the first to point out the importance of plasmoquine (since called pamaquin) in reducing the relapse rate, a feature which in this and other drugs was later to become a very important field of research. In collaboration with Hutton and Shute Sinton added greatly to knowledge of the newer anti-malarial compounds in the treatment of infections with the different parasites and in particularly in the search for drugs bringing about true causal prophylaxis, i.e., so acting that infection was prevented even when the parasite is inoculated by bite or otherwise. Among drugs so tested were stovarsol, pericrina 303, sodium stovarsol, quinine troposan, parosan dimeplasmine, atebrin, plasmoquine, certuna, proseptasine, and paludrine. There were many issues involved in such work. There was the question of effectiveness against the different parasites. There was the question of cure, i.e., complete elimination of infection, as against treatment of the attack, which however effective did not necessarily eliminate infection and so prevent relapses, one of the chief objectives in malaria treatment and one which quinine, though very effective against the attack, largely fails to do. There was also the question of the effectiveness of different drugs in prophylaxis and the degree to which a drug might be capable of true causal prophylaxis. In all these cases there was the question of dosage in treatment and in prophylaxis and many other issues to be determined. As a result of Sinton's and his collaborators' researches much valuable information regarding the treatment of malaria was obtained.

RESEARCHES ON THE MALARIA PARASITES OF MONKEYS

During 1932–35, Sinton, largely in collaboration with Harbhagwan and with Mulligan, carried out intensive researches on the plasmodial infections of monkeys, being among the first to undertake such studies and through them to be able to utilize experimental methods in the investigation of treatment and in other directions. In a series of papers the authors gave detailed descriptions of the parasites and their identification together with a critical review of the literature. By these studies they were able to learn much about the mechanism of immunity in malaria, the implications of multiple infections and super-infections and to estimate the effect of treatment upon the development of immunity. They were also able to demonstrate an intradermal reaction in such infectious. As a result of this and later work Sinton published in the *Journal of the Institute of India* (1939) a paper entitled 'A summary of our present knowledge of the mechanism of immunity in malaria'.

RESEARCH ON THE SYSTEMATICS AND STRUCTURE OF SANDFLIES OF GENUS PHLEBOTOMUS

Sinton's work on sandflies of the genus *Phlebotomus* began with his association with Professor Newstead at Liverpool in collaboration with whom he published in 1921 a paper entitled 'On a collection of Papataci flies (*Phlebotomus*) from India'. In 1923 Sinton published the first of a series of 36 papers dealing with Indian species of this genus the last of the series being in 1933. He also published descriptions of some species from other countries than India. In all some 27 species were described (24 from India and Ceylon) including 16 that were new to science. These descriptions were very thorough. running as a rule from 5 to 8 pages of print and dealing, not only with external characters, but with internal structure. It was in this last respect that Sinton's work was more especially notable and some of the important characters used in identification and recognition of species were structural features such as the pharyngeal armature, and in the female, characters of the spermathecae. Without this intensive study and the use of such characters identification and affinities of species would scarcely have been possible.

It was incidentally Sinton's work on the pharyngeal armature in *Phlebotomus* which led to the description by Sinton and Covell of the buccal cavity and pharyngeal armature in *Anopheles*, and by Sinton and Barraud of these structures in the Culicini. Especially in *Anopheles* the pharyngeal armature has been a particularly important character in identification and classification.

OTHER RESEARCHES

Sinton has made other contributions to science than those so far mentioned. He was one of the first (1917) to describe and give the stages of development of the parasitic trematode *Agamodistomum* in *Anopheles*, previously recorded only from *A. maculipennis* in Europe and now described by Sinton in the larva and adult of three species of this genus on the North West Frontier of India. He also early described other helminthic infections in this genus. Sinton in collaboration with Little (1925) was also one of the earliest to note the occurrence of the midge *Culicoides* as an ectoparasite of *Anopheles*.

Besides describing oriental sore in Russian Turkestan, Sinton, in collaboration with Shortt, was the first to record cutaneous leishmaniasis in a dog in India, canine leishmaniasis having been previously described only from the Mediterranean area. Later Sinton, in collaboration with Shortt and Swaminath (1935) obtained transmission of leishmaniasis to humans by the sandfly *P. argentipes* fed on oriental sore in a monkey and also successfully obtained transmission of cutaneous leishmaniasis by inoculation of humans from a natural lesion in a dog in India.

Though the study of endemicity in malaria has not been a special feature of Sinton's work he has nevertheless contributed papers dealing with surveys carried out in India and his recommendations to the Malaria Committee of the League of Nations on malaria conditions in the delta of the Ebro in Spain is an important contribution to knowledge of European malaria. Sinton was also joint author with the present writer of the 'Malaria map of India', published in the *Indian Journal of Medical Research*, giving the distribution of endemic and epidemic malaria in contours of intensity, a map that is almost, if not quite, unique for any tropical country.

Nor would mention of Sinton's contributions to malariology be complete without referring to the many helpful bulletins issued from the Malaria Bureau and the infusion of keenness and interest which Sinton aroused among those with whom he was associated. Here too should be mentioned the contributions that Sinton made in some of his papers regarding economic aspects of malaria. 'What malaria costs India' is deservedly famous and a remarkable summary of the economic effects of malaria, which the writer of an obituary has noted might appropriately be called 'What malaria costs the world' so extensive is its scope and documentation (Covell, *Brit. Med. J.*, 7 April 1956). To this might be added another remarkable paper entitled 'Man-made malaria', which Sinton read at the 13th All-India Congress of Medical Research Workers held at Calcutta in 1935 and which has probably never been equalled as a description of certain epidemiological features of malaria not often described or their importance realized. Another contribution has been 'Malaria in war', the Robert Campbell Memorial Oration read at the Ulster Medical Society in 1946. Sinton's appreciation in *Current Science* (1946) of the work of Sir Ronald Ross should also be mentioned, as also Sinton's bibliography of 2200 titles of papers and reports on malaria in India since Ross's discovery of the mosquito cycle, a work including many unpublished records of useful work which alone is an outstanding contribution to malariology.

During 1944–45, when in England before retiring, Sinton made many contributions that were published as helpful reports or circulars by the Army, as also by the Ministry of Health and by the Ministry of Transport giving information and instructions regarding precautions against malaria and its treatment. Some of these were for merchant seamen and ships' doctors. Some were translated for use in France. As in all Sinton's work and in whatever task he undertook there is evidenced in these reports and circulars a meticulous care and thoroughness that is very characteristic.

LIFE IN RETIREMENT AND PUBLIC HONOURS

Sinton in 1945 retired with the courtesy title of Brigadier, to private life on his estate at Cookstown, Co. Tyrone, Northern Ireland, with the intention to take up fishing and ornithology, pursuits for which he had always had a great liking. During his life in India Sinton must have had many opportunities when time and leave permitted to enjoy these hobbies, if so they might be called to watch the eagles at Kasauli circling the crags and perhaps to fish in some swiftly flowing Himalayan stream or to enjoy one or other of the many happy relaxations that India offers.

But soon Sinton was to enter wholeheartedly into local affairs. Interested in his old University, he became a member of the Senate in 1948, was Pro-Chancellor in 1952 and President of Queen's University Association 1953–54. He was Governor of the Royal Academical Institute, Belfast, 1946–50; President of the Co. Tyrone Branch of the Forces Help Society (formerly the Sailors', Soldiers' and Airmen's Help Society) 1946–52, and Vice-President of the North Ireland Branch of this Society from 1952. He was President of the Cookstown Branch of the British Legion 1946–53, member of the Council of the North Ireland Branch 1949–52, and reprensented North Ireland at the 11th Conference of the British Empire Service League at London in 1951. In 1946 he was made Hon. Member of the Royal Society of St. George. He was President of the Queen's University Service Club from 1946; Vice-President 1946–52 and President 1952–53 of the Old Instonians Association. He was Magistrate (J.P.) for Co. Tyrone from 1947; High Sheriff for that Country in 1953; and Deputy Lieutenant on 1954.

In the course of his service and in retirement Sinton received many honours and distinctions. Besides the Victoria Cross, the many Mentions in Dispatches and Medals for war service in the many campaigns in which he took part and the award of O.B.E. during his military service, he received many civil awards and distinctions. He received the Hon. Degree of MD of the Queen's University in 1917 and in the same year the Arnott Memorial Medal of the Irish Schools and Graduates Association. He was made Hon. Member of the Ulster Medical Society in 1920. He was awarded the Chalmers Medal of the Royal Society of Tropical Medicine and Hygiene in 1929 and was made Hon. Member of the National Malaria Society, U.S.A., in 1930. From 1943–46 he was a Member of the Malaria Commisson of the Medical Research Council and in 1944 was awarded the Bissett-Hawkins Medal of the Royal College of Physicians. He was a Vice-President of the Royal Society of Tropical Medicine and Hygiene 1945–47 and President of the Malaria Commission of the League of Nations 1937–46. In 1946 he was elected a Fellow of the Royal Society. In the same year he was Robert Campbell Orator and Medallist of the Ulster Medical Society. In 1949 Sinton received the Mary Kingsley Medal of the Liverpool School of Tropical Medicine. From the Egyptian Government he was awarded the Anti-Gambia Memorial Medal in appreciation of his services in the malaria epidemic of 1950. In 1953 he was made Hon. Fellow of the newly formed National Society of India for Malaria and Other Mosquito-borne Diseases.

As regards Sinton's personal qualities one has the impression of an acute and active mind, almost tireless in its many activities. He was greatly liked by his colleagues and socially he had a charm that with his natural kindness, generosity and reliability gained him many friends and admirers. He had an extremely high sense of duty and once he had made up his mind on a course of action he believed to be right he was not easily deviated from it, a characteristic that at times gave him a little of the proverbial Irishman's love of a fight. This did not prevent him, however, being popular with his colleagues and with those in authority. He was a great lover of children and animals and was essentially kind and gentle, a characteristic noted by the writer of one of his obituary notices and one regarding which the present writer is in agreement.

Sinton died on Sunday night, 25 March 1956 at his house in Cookstown, Co. Tyrone, at the age of 71, and was buried with full military honours among the mountains near his home. He leaves a widow and a married daugter.

RICHARD CHRISTOPHERS

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NIBARAN CHANDRA CHATTERJEE

(1890–1950)

Elected Fellow 1942

CHILDHOOD AND EDUCATION

NIBARAN CHANDRA CHATTERJEE was born at Ajmer in 29th December, 1890 in a highly respected Bangalee family. His father was a civil servant at Ajmer where young Nibaran had his early education. After completion of his schooling, he moved to Allahabad for higher education. He obtained his BSc degree in Biology from Muir Central College, Allahabad, where the celebrated entomologist Dr A D Imms was Professor of Zoology (later on elected FRS). Professor Imms had a profound influence on the impressionable mind of young Chatterjee. He accompanied Professor Imms to Dehra Dun, discontinuing further education, when the latter moved to Dehra Dun to assume the charge of the post of the Forest Zoologist, Imperial Forest Research Institute, Dehra Dun in 1911. Though Professor Imms shortly left India to join the University of Cambridge in 1913, Dr Chatterjee continued to work at Dehra Dun. It was Professor Imms who kindled in young Chatterjee the passion for knowledge and goaded him to take up research as a career which was not an attractive proposition even in those days. The influence of Professor Imms remained everlasting. The relationship had been the traditional "guru" and "shishya" type. Unfortunately, Professor Imm's tenure was short one extending only upto sixteen months.

During the short period of Professor Imm's stay in FRI, Dehra Dun, Dr Chatterjee ably assisted his teacher and the precept in bringing about valuable reforms in the organization of forest entomological research in India which included extensive addition to the entomology library, and intensive survey of insect pests of forest and arranging their identification by renowned international specialists to build an authentically catalogued reference collection of forest insects, a *sine qua non* for any economic entomological research, designing of the insectary and the entomology laboratories. Dr Chatterjee's contributions at the formative stages of the establishment of the Forest Entomology Branch at the Forest Research Institute were invaluable, though largely remaining unrecorded. While working at the Forest Research Institute, Dr Chatterjee obtained the Associateship of the Indian Institute of Science, Bangalore (AIISc) and subsequently in 1938, DSc degree from the University of Bombay for his outstanding contributions to the entomological aspects of spike disease of sandal.

N C Chatterjee

SERVICE AND RESEARCH CAREER

The entire service and research career of Dr Chatterjee were spent at the Forest Research Institute, Dehra Dun where he joined as an Assistant to the Imperial Forest Zoologist (renamed Forest Entomologist in 1922) on November 10, 1911. He was promoted to the post of Assistant Forest Zoologist (Entomologist) in 1920 and retired in that capacity in December 1945. However, in March 1948 he was re-employed as Forest Entomologist, a post which he held up to November 10, 1949, a date, by a curious coincidence, identical with the date and month on which Dr Chatterjee first joined service in the Institute. Another strange coincidence is that he was succeeded by Dr M L Roonwal, another pupil of Professor Imms.

In addition to research, Dr Chatterjee also taught forest zoology and forest entomology to the probationers of the Indian Forest College for about two decades. He was an outstanding teacher by any standard and could make the subjects like zoology and entomology highly interesting to the probationers for whom these were of just peripheral interest. Some of his students could recall important aspects of forest entomology even after a lapse of many decades. His mastery over the language and profound knowledge of forest entomology rank even today as the model of excellence in teaching in the Indian Forest College.

Dr Chatterjee's scientific work broadly falls into four major categories, *viz.* on the lac insect (*Kerrya laca*) which he did in collaboration with Professor Imms, entomological investigations on the sandal (*Santalum album*) spike disease which earned him great laurels, on insect pests of lantana for its biological control and borers of felled timbers and their control.

The first publication of Dr Chatterjee appeared in 1915 on the influence of kusum (*Sleichera oleosa*) oil on *Serinetha augur* (Coreidae). In the same year, he published, in collaboration with Professor Imms, a classical monographic work on the morphology and biology of the lac insect which to-date remains the standard work on the subject. It has been cited even in some current text-books on entomology published in India and abroad. Between 1915 to 1925, Dr Chatterjee, in collaboration with Dr C F C Beeson (FNA, the then Forest Entomologist), worked on various forest entomological problems. In 1925, Chatterjee and Beeson published another epoch-making monographic work on the economic importance and control of the 'sal' (*Shorea robusta*) heartwood borer (*Hoplocerambyx spinicornis* Newm.) which was causing unprecedented loss to the 'sal' forests. The most outstanding contribution had been the trap tree method to control the heartwood borer of sal. This was based on the serendipitous discovery that adults of *H. spinicornis* were attracted, from a long distance to freshly oozing sal sap. Detailed inventory of the economic loss was also prepared. Considering that loss-estimate was a newly emerging concept in those days, this was no mean achievement. The efficacy of the trap-tree method to control one of the most serious forest insect pests has stood the test of the time admirably and even after six decades of its discovery, trap-tree method is routinely followed annually in most 'sal' forests of the country to keep the population of the 'sal' heartwood borer at an endemic level. Several epidemics had been contained and controlled by implementing the recommendations of Dr Chatterjee since 1925, thus saving several billions of rupees. In the opinion of Dr Beeson, the benefit that accrued by controlling recurrent epidemics of the 'sal' heartwood borer far outweighed the entire expenditure on research in forest entomology in India at that time. What else can be a better tribute? The most rewarding and satisfying period of research for Dr Chatterjee had perhaps been from 1930 to about 1939 when he was engaged in the entomological studies in connection with the investigations on the spike-disease of sandal in South India, a field which having been absolutely virgin, was both a delight and challenge to any competent scientist. During this period, spaning nearly a decade, he conducted many investigations on the insect fauna associated with sandal and on the suspected role of some of the species in transmitting the spike disease. To date his had been the only exhaustive work on insect fauna associated with a single tree species in the whole world. For the collection of insects visiting sandal, very simple and inexpensive technique *i.e.* stickly papers was used and this technique, though currently sophisticated in several countries, till remains the bed-rock for this type of investigation. Dr Chatterjee's profound knowledge of the taxonomy of various groups of insects is undoubtedly reflected in the taxonomic account of insect fauna of sandal trees as evidenced in his various publications on the subject. In a few cases, he collaborated with such international stalwarts like I Chopard and TV Ramakrishna Ayyar. Although Dr Chatterjee had not been able to incriminate conclusively the vector/vectors of spike disease of sandal, nonetheless he laid a strong foundation by his meticulous and painstaking collecting and collating valuable information on taxonomy, biology and ecology of sandal insects with Boswellian thoroughness. Subsequent investigations on this vexed problem were/are built up on this solid foundation.

Soon after the completion of his studies on the entomological investigations of spike disease of sandal, Dr Chatterjee looked into the possibilities of controlling the *Lantana* weed through the agency of indigenous insects feeding on it. He published a paper in 1940 dealing with the biology, distribution and alternate hosts of fifty four species of insects feeding on *Lantana* in Dehra Dun. This publication ranks only next to the monumental work of Dr Y. Ramchandra Rao entitled *Lantana Insects in India,* both in content and merit. Any serious investigator on the biological control of *Lantana* cannot help but to consult these two *vade meca.*

Dr Chatterjee investigated, in great depth, the biology, ecology, feeding habits and control of *Urostylis punctigera* Westw., a pentatomid bug, damaging champa (*Michelia champaca*) forests in North Bengal. Unfortunately, detailed account was not published for reasons unknown. However, a summary of the important observations coupled with preventive and remedial measures was published by Dr Beeson in 1941 in his book on *Forest Insects.*

From 1948 to 1951, Dr Chatterjee published a series of papers on insect pests of freshly felled logs and converted timbers. During the postwar period, these aspects assumed considerable importance in view of the scarcity of timber resources even at that time. His successors followed up the investigations for another decade. These researches have made possible to extract timber from the felling sites free from insect damage, thus indirectly conserving the valuable timber resources of the country.

Though the official position held by Dr Chatterjee was not a very elevated one at the present standard, he was the recipient of many scientific and social honours and distinctions. He was honoured as "Rai Bahadur" by the then British Government of India. Dr Chatterjee was elected Fellow of the National Institute of Sciences of India (now Indian National Science Academy) in 1942, at a time when only a few entomologists were Fellows of the Academy. He was one of the Founder Members of the Entomological Society of India and served this Society as Vice-President during 1940-42 , 1944 and 1950 and as President in 1943. From 1942-44, he was the Managing Editor of *Indian Journal of Entomology*, of which he was a Member of the Editorial Board during the years 1939, 1940-41, 1948-49. In recognition of his outstanding contributions to entomology, he was elected President of the Zoology and Entomology Section of the Indian Science Congress for the year 1951. It is rather sad that illness, culminating ultimately in his death, prevented him to fulfil this obligation. He remained to the last days of his life a very amiable and considerate person to both high and low.

FAMILY

Dr Chatterjee's first wife predeceased him issueless. He married second time late in life and at the time of his death he was survived by his wife and six children (five sons and one daughter) who were young but are now well placed.

CHATTERJEE AS A MAN

Dr Chatterjee was tall (about 6′–2″) and stoutly built, with a pleasing countenance and enjoyed good things in life. An accomplished instrumentalist, he always found himself at ease in the company of the maestroes. He had always been a star attraction in any musical function held at Dehra Dun. In the field of sports, he excelled in the games of soccer, tennis and cricket. He was also an enthusiatic angler and an excellent hunter. In social life, Dr Chatterjee enjoyed a previleged position in Dehra Dun which used to be largely inhabited by retired top brass of Defence and Civil Services. He was a very popular figure among the elites of Dehra Dun town and had a wide circle of friends and admirers from almost all walks of life. He was a fine host and generous to a fault. During his short period of stay at the Indian Institute of Science, Bangalore, he cultivated good relations with the academicians of that Institute and had a large band of intimate friends who missed him when he left Bangalore at the end of his official assignment. He settled down at Dehra Dun where he built a spacious Bangalow having a big garden with a large number of fruit trees. Dr Chatterjee was a person with a great sense of self-respect and dignity. Even the British Officers used to respect him on account of his righteousness and frank speaking. He was ever-eager to uphold the cause of Indian Officers, often to the detriment of his career advancement, a rare quality even in those days, it is said. Though he had many tiffs with his British colleagues, they never failed to respect him as a "gentleman". Though a hard task-master, he always protected his subordinates from being subjected to indignation from the British Officers. Some of his subordinates who are still alive and reside in Dehra Dun, recall with a sense of pride and admiration their association with Dr Chatterjee, a living testimony to the quality of his heart and mind. In his social and professional life, Dr Chatterjee endeared himself to one and all who came in contact with him. Throughout his life Dr Chatterjee had verily believed that :

> "Honour and shame from no condition arise,
> Act well your part : there all the honour lies".

Dr Chatterjee breathed his last on February 20, 1950, at the age of 60 after a brief-illness. Even to the last day, he was wedded to the entomological persuits.

P K SEN-SARMA

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HEM SINGH PRUTHI

(1897–1969)

Foundation Fellow

HEM SINGHI PRUTHI was one of the distinguished entomologists that India has produced. With a brilliant academic career, he made significant contributions both in applied and basic researches. He had a long scientific experience extending nearly half a centuary (46 yrs) during which he devoted his energy and knowledge to the advancement of entomology in India. He was an able administrator and a leading organizer of anti-locust operations in desert region of Rajasthan.

EARLY LIFE AND EDUCATION

Hem Singh Pruthi was born at Deska Village (District Sialkot) now in Pakistan on February 23, 1897. He was the only son of a village farmer. He had his early education in a village school, where he stood first in each standard and passed his matriculation in First Division. For this achievement, he was awarded scholarship for continuing his pursuit at Government College, Lahore. During his school days, he used to mix with fellow students of all communities. He completed his BSc (Hons) in Zoology in 1918 with distinction and stood first in the Panjab University. He did his MSc in 1920 in first Division. He was the first student who took up writing thesis in MSc on an entomological problem. To achieve the same, he went to Imperial Agricultural Research Institute, Pusa (Bihar) and wrote up a thesis on 'Anatomy of Red Cotton Bug (*Dysdercus* sp.)' in 1920 and there he came in contact with M A Afzal Husain, an eminent agricultural scientist, who later invited him as Assistant Professor of Entomology at the Agriculture College, Lyallpur (Now Faislabad in Pakistan) in 1920.

As a young man, Pruthi was not content with achieving such a progress. His vision was scanning the horizon for higher distinction and education. After obtaining a travel grant from Educational Trust of Gurudwara Prabandhak Committee, he sailed for United Kingdom and joined the Cambridge University for his PhD (1920-1925). At Cambridge he was awarded the coveted research studentship of Charles Aberchombic. After obtaining his Doctorate, Dr Pruthi returned to India in 1925 and joined the Indian Museum, Calcutta, as Officer-in-Charge of Entomology Division.

PROFESSIONAL CAREER

Dr Pruthi's stay at the Indian Museum, Calcutta from 1925 to 1934 became a stepping stone for higher distinction in the field of Applied Entomology in India. He

later succeeded T B Fletcher in 1934, as Imperial entomologist at IARI, Pusa (Bihar) to become the first Indian to occupy the position of Imperial Entomologist at the young age of 37 years and worked in this capacity from 1934 to 1943. Because of an earthquake at Pusa (Bihar), the Institute was shifted to New Delhi in 1936. Imperial Agricultural Research Institute (now Indian Agricultural Research Institute) then became the nerve centre of Indian entomology under Dr Pruthi. From 1944 to 1945, he officiated as Director, Indian Agricultural Research Institute (IARI), New Delhi. As Imperial Entomologist, he was also heading an infant cell called Central Locust Organization and also served as Plant Protection Advisor to the then British Government. After the great Bengal Famine (1943), British Government appointed a Woodhead Famine Commission in 1945 which recommended the establishment of a comprehensive organization for preventing the damage by pests and diseases to various crops in the field and during storage in India. The Commission commended the work of Central Locust Organization headed by Dr Pruthi with the remarks that the work had shown how a difficult pest (locusts) could be definitely controlled by a good organization with simple and efficient techniques. While still at IARI, he was assigned the duty as Plant Protection Advisor to the Government of India in October, 1945 for preparing a scheme of work for the coordinated control of all important plant pests and diseases of crops in India. The scheme and proposals put forward by Dr Pruthi were accepted and a permanent Plant Protection and Quarantine Organization was established in May, 1946 and Dr Pruthi was appointed its first *ex-officio* Director. The name of the Organization was later changed to Directorate of Plant Protection, Quarantine and Storage. The Central Locust Organization at IARI was amalgameted to the New Directorate. In 1947, the Storage Directorate of the Ministry of Food was also transferred to this New Directorate. As Plant Protection Advisor (PPA), Dr Pruthi assisted various States in India in establishing their own respective Plant Protection Departments. Thus, a great leap was taken in Applied Entomology in India under the stewardship of Dr Pruthi adding another feather in his multifarious achievements. He continued as Plant Protection Advisor to Government of India and Director of Locust Control till his retirement in December, 1953. Later in 1954, Dr Pruthi was invited by Diwan Chiman Lal, Vice-Chancellor, Punjab University to chair the newly created School of Entomology at the University. There he guided several students for their MSc dissertation. He left the school for taking up a new assignment offered by ICAR for writing a comprehensive, "Text Book on Entomology". A monumental work was presented by him in the shape of "A Text Book of Agricultural Entomology", which came out in early 1969 and went out of print immediately—a final crown to a dedicated and devoted entomologist.

Contribution to Entomology

Basically trained in anatomy, morphology and taxonomy, Dr Pruthi was equally at home in applied entomology. He devoted his voracious energy in the overall improvement of entomological sciences in all respects including teaching. From his numerous brilliant publications, it is revealed that his major contributions were on (a) Economic entomology (b) Biological control of insect pests (c) Termite research and control (d) Studies on pests of wheat (e) Damage potential of insects in sugarcane (f) Studies on the pests of fruit and fruit trees (g) Studies on the pest of oilseed crops (h) Studies on the pests of cotton (i) Taxonomic studies on the Homopterous groups of insects (j) Studies on the storage pests (k) Desert locust control in India and finally (k) Studies on insecticides. He had a wide perception of subjects, which showed the intensity and deep thrust knowledge of the entomological problems facing the country during his time.

As the first Indian to occupy the chair as Imperial Entomologist, Dr Pruthi's activities increased multifold. With the transfer of IARI from Bihar to New Delhi, the Institute started attracting considerable public attention and Dr Pruthi had to modify his programme drastically and directed his attention to economic entomology. He organized, counselled and guided the research, field activities and experiments on various aspects of entomological problems facing Indian agriculture in a systematic manner. The Division of Entomology at IARI was at that time in its infant stage. He initiated and enriched the National Pusa Collection, which was one of his obsessions. Today, the Division of Entomology has established itself as one of the leading centres of reference and identified collection (known as National Pusa Collection). During his stay at IARI, he opened a regional station at Karnal for studies on insect ecology and their control. At that time Imperial Entomologist was also responsible for examining entomological work meant for publication. He also acted as Adviser to Central Government on the aspect of entomological problems in India. On the advice of Dr Pruthi, ICAR sanctioned a large scheme in 1930 on the researches and on the survey of the permanent breeding areas and the biology of desert locust. A breakthrough indeed in containing the locust swarm damage in India. After the termination of the scheme in 1939, the Government of India established a permanent Locust Warning Organization under the charge of Dr Pruthi at IARI with field headquarters at Karachi for keeping a constant watch on the fluctuation in the locust population and to enable the Imperial Entomologists to warn the States of any fresh outbreak and render advice for the control of incipient swarms. After the experience (1940-1941) of locust swarming activity in India, Dr Pruthi realised that more vigorous efforts are required for locust control than merely rendering advice to States. In 1942, a plan called the Coordinated Anti-locust Scheme was formulated under which Dr Pruthi was assigned the responsibility for the control of locust in the desert breeding areas in cooperation with local revenue authorities. Thus a sound beginning was made to control locust in its breeding areas. It was, indeed, a great credit to an entomologist who had farmers love in his heart. Later in 1946, the locust wing at IARI was transferred to the newly created Plant Protection Directorate under Dr Pruthi as Director, Locust Control. The credit for establishing such a sound locust organization which is considered to be one of the best in the world goes to Dr Pruthi.

On the plant protection side, although researches on insect pests and diseases affecting crops were being undertaken in India since 1905 but efforts to carry the result thereof to cultivator's field did not make much impact tlll 1942. Dr Pruthi foresaw that the land area available for cultivation, for various reasons, was limited and the demand for produce grown on it was steadily increasing so that attempt to wiest more and more out of a unit of land became inescable. This was the challenge that faced agriculture in earlier decades and even today more than ever before. According to Dr Pruthi, "Plant (crop) protection" is the science and technology of protecting growing crop and stored agricultural commodities from their natural enemies. After the Second World War and with advent of DDT and BHC, a revolution in insect control became possible and practical. Dr Pruthi visualised the future role of insecticides in the agro-economy of the nation. How correct was his vision can be judged from the figures of insecticides imported or manufactured in India earlier and in recent decades. His major contribution in this respect was that he usured in the era of pesticides in Plant Protection.

The mantle to transform this "plant protection energy" for fruitfully exploiting it in controlling pests and diseases and involving farmers in this protection technology fell on Dr Pruthi and to his newly created Organization. Constraints were numerous, lack of trained personnel and import of pecticides and plant protection equipment were to be arranged to promote and coordinate plant protection activities all over the country either as advisory or at functional levels. By his tremendous efforts Dr Pruthi surpassed all these difficulties in no time and today the Directorate with its multifarious activities has achieved an important status in the land mark of Indian agriculture. As among the agricultural production programme, plant protection is one that yields the maximum benefits within the shortest time. Dr Pruthi recognized plant protection as an essential condition of successful and profitiable agriculture. The Directorate at its initial stage had only two wings—that of antilocust and quarantine wing to which the storage wing was also attached later. In 1951, Dr Pruthi also opened several plant protection stations (centres) apart from State Agriculture Departments at almost each and every state of the Indian Union. These stations provided technical expertise, equipments and insecticids to any farmers on subsidised rates. Thus, Dr Pruthi was able to create a plant protection umbrella for the protection of crops throughout India. The quarantine stations at major seaports and air-ports ensured that no exotic pests entered India. His love for farmers and agriculture made Dr Pruthi to initiate aerial control operations in India as early as in 1944, when an aircraft loaned by War Department was used for reconnaissance purpose for locust hoppers and swarms. A great technological advance indeed for the new Directorate. The role of aircrafts against large scale epidemics involving vast areas was visualised and recognised by Dr Pruthi. Later on Dr Pruthi's insistance during 1951, three fixed wing aeroplanes were obtained from USA under Point Four Programme of Technical Assistance. Dr Pruthi was thus able to establish an aerial wing attached to the new Directorate. Today the aerial wing of the Plant protection is functioning as a full fledged separate organization with a fleet of several types of aeroplanes and helicopters fitted with spray equipments for aiding plant protection work in vast areas of the country in containing insect pests and diseases. During Dr Pruthi's time, 75% of the locust control was fully mechanised including the use of aircrafts.

While inaugurating the Delhi branch of Entomological Society as its President way back in 1938, Dr Pruthi said, "Today is an important occasion in the history of Indian entomology as the aim of the Society is to take a leading part in the development of entomological science both pure and applied". Dr Pruthi often used to say that "Farmers are in close touch with the fountain of life (crops) and they need "protection" foı their life. This statement is still valid today.

On the research side, his publication on Homopterous and Orthopterous (particularly locusts) group of insects are considered today as an excellent and brilliant contributions. His earlier work in 1924 on the morphology and description of male genitalia of Homoptera brought him international recognition and his work has been quoted in "A general Text Book of Entomology" by A D Imms. His monumental work on Indian Jassids (1924-25) is considered today as an important reference work in this group for young aspirants. In 1940, he described eight new species of *Empoasca* (Jassidae). Earlier in 1926 he described several species of the genus *Homoeocerus* (Coreidae). In 1924 he worked out the post-embryonic development of male genital organs of *Tenebrio molitar* (Coloeoptera). He followed the development from larval rather than pupal stage as was being done earlier and elucidated its homology with that of Homoptera. In 1937, he described the male genitalia of *Pyrilla* spp. On insect ecology an important contribution was made by him on the effect of different temperature, starvation and carbon-dioxide on the metamorphosis in insects. Again (in 1941) he studied the fatal temperature for the cotton pink bollworm. In 1945-47 new methods of computing pest incidence and insect population studies came out from his mighty pen. From 1938 to 1940 and 1960 important contributions on pest of fruits and fruit trees of North-West-Frontier Province, Phyto phagous chalcidoid and insect and mite pests of citrus were made. In 1951 an exhaustive publication on "San Jose Scale in India" was published. He studied the biology of 'AK' gıasshopper in 1939. In 1949, he gave a general account and control of *Hieroglyphus* sp. and *Colemia* sp. On pests of sugarcane, he presented statistical data in 1939 about the losses caused by different borers and termites to mature sugarcane crop. On stored grain products, in 1948, he published an exhaustive account of the storage pests occurring in India and other countıies. This information is being utilised even today for teaching and identification. In 1940 he wrote a paper on methods of fumigation and disinfection of plant material at Indian Seaport and Air-port and threw light on the indiscriminate and wanton use of insecticides. As early as in 1938, Dr Pruthi recognized the role of insect predators and described Dipterous predator *Leucopis griscola* of *Aphis gossypii.* In 1958, he elucidated the recent termite researches in India and in 1962 published a review work of progress in beekeeping in India covering the period 1929-54. Between 1952 and 1956 in several important contributions, he gave comparative efficacy of different insecticides like technical BHC, Lindane, Aldrin, Dieldrin and Malathion both as dusts and spray for anti-locust operations. These efficacies were determined at different temperature and its recommendations are still valid today at local conditions. He also compared ground and aerial spraying and suggested that fixed wing planes are not useful particularly for settled swarm and hopper bands. He also suggested where and how to employ the type of air-craft for obtaining better results. He not only worked out the average lethal dose against all the stages of locust but also compared the cost involved in ground and aerial spraying.

Dr Pruthi's major contribution for Indian Agriculture and farmers was his sincere fight against desert locust. He waged a relentless war against this migratory international pest whose damage potential surpass all the known insect pests. Even during his prime old age, he remained very vigorous on locusts and roamed the terrible and inhospitable desert in ecastacy. Young technical workers in the desert marvelled at the stupendous energy displayed by Dr Pruthi. In 1950, he published "The Desert Locust Cycle of 1940-46 in India, its Progress and Control". A monumental work which included several new information on locust ecology and swarm migration to India in relation to meteorology. It became a handy guide for technical officials in the field controlling locusts. Dr Pruthi organized anti-locust operations on war footing with fine precision of an army commander. All over the desert were established circle, zonal and technical field centres and outposts manned by skilled, dedicated and devoted young scientists provided with a net work of wireless sets and various types of vehicles fitted with power dusters/sprayers under the overall in-charge of Locust Sub-station at Jodhpur with Headquarters at New Delhi. He obtained and created such unique facilities for staff in an otherwise inhospitabe desert. Under Dr Pruthi, the locusts could not create that sort of terror which it was known to hold earlier and normally associated with famine. India heaved a sigh of relief and occurrence of famine due to locusts became a historical past. All this was due to Dr Pruthi and his single handed efforts. A crowning glory indeed for a man born and brought up in a small village.

Dr Pruthi's deep involvement in agricultural entomology made ICAR to assign him, for filling up a long felt lacuna in entomology, to write up a text book in insects and Dr Pruthi gave his last contribution to entomology by contributing "A Text Book of Agricultural Entomology" (pp. 1—977), which came out in 1969. This was his last monumental work which is complete in itself and covers practically all aspects of entomology. The book was well received and shortly went out of print.

HONOURS AND DISTINCTIONS

Dr Pruthi, apart from being a devoted scientist, was a great organizer. He gathered together eminent scientists of the country working in different disciplines for organizing a National Science Academy (now Indian National Science Academy) in 1935 and became one of its Foundation Fellow. This, indeed, was a leap forward for Indian sciences. He was a Member of the Executive Council of the Academy for the years 1945-46, 1953-54 and 1956. He worked as its Secretary during the period

1947 to 1952. Simultaneously a long felt vaccum in the science of entomology was gathering storm among the entomologists in the absence of any dignified forum for its advancement. This gap was filled up by the creative enthusiasm of Dr Pruthi and thus in the year 1938 along with other eminent entomologists of the country, he founded the 'Entomological Society of India, under the presidentship of M A Afzal Husain, FNI and Dr Pruthi became the Chief Editor of the *Indian Journal of Entomology* from 1938-41 and President of the Society in 1940 and again from 1948 to 1950. Dr Pruthi organized and attended various international conferences to discuss problems concerned with locust control since 1936. At his suggestion in an International Conference on locust held in New Delhi in 1950 which brought FAO into picture which included in its programme of work for the promotion of international coordination of locust control.

Dr Pruthi presided over Indian Science Congress held in 1940 and delivered talk on "Ecology and Control of Insects". His thought provoking note on the coordination of research in agricultural entomology in India was well received. He laid great stress on the need of fundamental research on insects in his Presidential address at the meeting of Entomological Society of India at Allahabad in 1940.

Dr Hem Singh Pruthi was a recipient of OBE, awarded by British Government for the uplift of agricultural sciences in India. The Cambridge University conferred on him ScD degree in recognition of his outstanding research work.

PERSONALITY AND QUALITIES

Dr Pruthi had an adaptable and adjustable nature and was able to work without any constraints in any environment. He always remained meticulously dressed in westernised fashion but remained a true sikh to the last. His was a hard working and winning personality and he enjoyed his field trips all over India and felt content in far off secluded places like Thar desert in India. He was an able administrator without malice, a great organizer and never shriked from responsibilities which he had to share with many. He was happiest in the field and nature and took time away from his official trips to study locust ecology in depth or for conducting newer insecticidal trials in desert.

His towering personality was caged in a short statured anatomy but with his deep resonant throated voice this handicap was overshadowed. He was always respected by his colleagues and they always held him in admiration. He had a neck to scout out the talents in the country. He remained an indestructable wall against an international pest like locust in its eastern limits. In his later years, he was so keen and involved in this problem that he used to pass all important religious festivals and stay in the fields and kept his staff engaged with him without the least murmur from them. Such was the great regard towards him by his staff and co-workers. The number of workers trained by him achieved great success in life in other organizations like FAO etc. He remained a pillar of strength which others imbided. He always inspired others and recognized the value of hard work. Because of his multifarous activities and his involvement with various other scientific societies and his invariable presence in local and international conferences gave him not much time for writing papers but still he published over hundred brilliant publications.

Dr Pruthi, though a strict disciplinarian, had a very kind and sympathetic heart and loved to encourage young students, scientists and technical staff and realised the difficulties faced by the staff. He trained each staff member for injecting intravenous injuctions against snake bite in the desert because no medical facilities were available at remote places. He was considerate to the extreme while listening to their problems and hardship and even at times pressed the Government to rectify the grievances of the staff posted at far off places. He had a sharp memory and recognized faces and knew the staff by name. By his passing away on December 23, 1969, India lost a towering stalwart in the field of agricultural entomology, a zealous and devoted scientist and a forceful organizer. His loss will be mourned by all who knew him, worked with him and shared his inspirations.

R K BHANOTAR

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TSVenkataraman

TIRUVADI SAMBASIVA VENKATARAMAN

(1884–1963)

Foundation Fellow

"I have not so far seen anything so wonderful as this", remarked His Excellency The Viceroy of India, Lord Irwin, after visiting the Sugarcane Breeding Station (now Institute) and listening to the fine exposition from the Head of the Station, 'the squint eyed, short, rather uncouth scientist' T S Venkataraman. This was followed by a Viceregal order in 1927 that all workers in sugarcane in the country must pay a visit to this Mecca of sugarcane. The next year saw the conforment of the title 'Rao Bahadur' on Rao Sahib T S Venkataraman in appreciation of his contributions towards sugarcane research.

"Here is my resignation" quipped the young Botany Assistant, T S Venkataraman with an independent outlook and hurt at the treatment meted to him, and handed over the bit of paper to his boss Dr C A Barber, an Englishman. Fortunately for science, this resignation letter and another to follow were neither pressed nor accepted and this young man became one of the foremost agricultural scientists of all time.

EARLY LIFE AND EDUCATION

TIRUVADI SAMBASIVA VENKATARAMAN was born in June, 1884 at Salem in Madras Presidency (now Tamil Nadu). Born in an orthodox, religious, brahmin family, Venkataraman, right from his childhood was initiated into the scriptures and epics in Sanskrit. Though initially the boy took keen interest in religion, soon he developed a catholicity of views much to the consternation of the parents, who had initiated him early into the 'Brahmacharya' stage with the sacred thread ceremony. By the age of 16, the boy had practically turned an aethist, renouncing religion and discarding the sacred thread. Venkataraman's schooling was at Tiruchirapalli, the centre of missionary activity and where education was at its best. Brilliant as he was, he always stood at the top of his class. However, his deep interest in philosophy and literature led him to spend many hours in discussion with his friends resulting in neglect of his studies and failure in the SSLC examination. A year later, with the completion of the SSLC and then the pre-graduate course, Venkataraman moved to Madras for his degree course at the prestigious Presidency College. In taking botany as his subject for the BA degree, a subject not much in favour with students in those days and chosen as a last resort, he was influenced by the writings of Herbert Spencer. A firm believer in *Ahimsa*, he abhored zoology with its dissection of frog, cockroach, earthworm etc.

SERVICE AND RESEARCH CAREER

The year 1905 witnessed the graduation of Venkataraman from the Presidency College, with a first class, first rank in BA (Botany). He opted for the MA postgraduate degree in Botany at the Madras University having secured a stipend. This was shortlived with his appointment during the year as Assistant to the Government Botanist at the Agricultural College, Saidapet, Madras on a paultry salary of Rs 50 per month. The shifting of the College in 1908 to Coimbatore resulted in his moving to Coimbatore which is to become the centre of his research activity for the next 35 years. Much to his dislike, teaching was his major activity with research only at leisure moments. His aptitude and flair for research were evident early in his career when he submitted a dessertation on 'Disinclination of the passed students of the Agricultural College to take to farming, its causes and remedies' which won him the coveted Munagala prize. The article displayed his keen sense of observation of human nature, the difficulties of the farming community and the role of agricultural education. Sensing his inclination for research, Dr Barber had him transferred to the research section divesting him of all teaching responsibility.

An incident illustrating his enthusiasm for research and how it was thwarted by his boss is mentioned in the STA publication and must be recorded here. In a plot behind his residence, Venkataraman planted brinjal and was engaged in crossing two varieties outside office hours. Hearing about this, Dr Barber issued a stern warning to him and had the brinjal crop destroyed. Mentioning this incident, Venkataraman says "Those were Lord Curzon days when all the 24 hours of a government servant were considered to belong to the Government and the danger of this particular activity resulted from the assumption that energies thus spent would take off from official work".

A biography of Venkataraman would be incomplete without a mention of the position of the Indian Sugar Industry in the early 1900 to appreciate his gigantic contributions towards the present happy position when we can claim to be the largest producer of sugarcane and sugar in the world. At the start of this century, the import of Sugar from Java (Indonesia) drained the Indian exchequer to the tune of crores of rupees. This was mainly due to the fact that the per unit yield of sugarcane in the country in the main sub-tropical belt was miserably low with the industry unable to compete with Java industry. It was with a view to improve the yield of the indigenous sugarcanes that the decision was taken by the Government of India to start sugarcane breeding in the country. Only two countries, Java and Barbados were engaged in this research at that time. Coimbatore was chosen as the climatic conditions were ideally suited for flowering and setting of fertile hybrid seed. Dr C A Barber, the Botanist to Madras Government stationed at Coimbatore was appointed by the Government of India to the post of Government Sugarcane Expert at the Sugarcane Breeding Station, Coimbatore on October 25, 1912. At that time Dr Barber had two assistants with him whom he used to refer as the two jewels in the section—Dewan Bahadur K Rangacharya who later became the Systematic Botanist to The Government of Madras and T S Venkataraman.

When Dr Barber moved over as Government Sugarcane Expert, he took with him one of the jewels, T S Venkataraman, as his Assistant to start the breeding work in sugarcane, which is to bring so much credit and glory to this country. It was the first attempt in the sugarcane world to improve sub-tropical sugarcanes suited to the rigours of the climatic conditions—high temperature, low temperature, waterlogging, salinity etc. The two scientists, Barber and Venkataraman had an uphill task to perform.

As we now know, the success was achieved by the use of the wild species of sugarcane, *Saccharum spontaneum* (Hindi-*Dharba*) in the breeding programme to evolve varieties tolerant to the climatic and soil factors. How this idea of utilisation of the wild species occurred to the scientists is an interesting story. Gregor Mendal said "Out of the simplest things shall ye know the truth". How prophetic in the case of sugarcane. An evening walk along the channel bund by the side of the campus where the wild sugarcane was merrily growing gave the idea to use the wild cane in breeding. Truly, "the ability to observe what happens, to understand what is observed, to use the information to discover new ideas is the hall mark of scientists". Thus, Dr Barber and Venkataraman became the first scientists in the world to use the wild species in the breeding programme for improvement of crops.

VENKATARAMAN'S CONTRIBUTION TO SUGARCANE BREEDING

To Venkataraman goes the credit for saving from destruction the first ever batch of sugarcane seedlings raised in the country. During the first year, all the seedlings arising from the hybridisation of the two species. *S. Officinarum* × *S. spontaneum* failed to survive. Next year, Dr Barber was away on a tour of North India and Venkataraman raised the hybrid seedlings under ordinary field conditions and spotted a few, unlike any ordinary grass seedlings. The excitement that these may be true sugarcane seedlings brought Dr Barber hurrying to headquarters in response to a telegram. On examination, Dr Barber felt they were not sugarcane seedlings and irked that he had been made a fool conveyed his displeasure to Venkataraman and ordered the seedlings to be destroyed. Venkataraman was positive they were sugarcane seedlings and when his boss cooled down, obtained his approval to keep the seedlings on the clear understanding that no official time and energy would be wasted on them Lo ! in a few months much to the exuberation of all, the seedlings developed sugarcane joints Thus, in the words of Venkataraman "the sugarcane seedlings came into being in our country unknown, unhonoured and unrecognised". Dr Barber at once recognised the role of Venkataraman and recommended an advance increment for his intuition and personal interest in the work. It was turned down by the Government of India for its being against rules.

Venkataraman took over as Head of the Sugarcane Breeding Station in April, 1919 after Dr Barber proceeded on leave preparatory to retirement. He was merely in-charge of the station while efforts were made to secure a thoroughly qualified expert from Europe. Fortunately for sugarcane research in the country, no suitable foreign expert was available and Venkataraman was allowed to continue and later made permanent, from which post he ultimately retired in 1942. He was raised to the gazetted rank in 1918. Venkataraman may be said to be the pioneer and the earliest worker to study the root system of the sugarcane crop in detail, a study so difficult because of the invisible root system below the soil but so important to understand the productivity of the crop, particularly under stress conditions. By simple unorthodox techniques using earthen pots and glass bangles for supporting the sugarcane sets, the scientist was able to show that studies on root system can be conducted in detail and varieties with desirable root system isolated for use in breeding. We now know that considerable importance is attached to the study of the root system of crops. When the Governor of Madras, Lord Willington visited the station, he was shown the experiments on root studies and Venkataraman ended the explanation with the remark "I tackle the problem at its root, my Lord". Later Willington remarked that "the squint eyed scientist at Coimbatore is doing a wonderful job".

An interesting anecdote regarding the root studies to prove the independent and straightforward outlook of Venkataraman despite the British heirarchy at the time is worth mentioning. In 1916, Mr Howard, holding the topmost post of Economic Botanist to the Government of India, presiding over the agricultural session of the Indian Science Congress claimed to be the first to study the roots of cultivated crops. Dr Barber who was present remained silent, but Venkataraman challenged the statement with evidence. This was not forgotten, for years later, when Venkataraman visited the Agricultural Institute at Pusa, he was refused permission into the botanical garden. "You are the young chap who had the audacity to contradict me", he was told.

Breeding work in sugarcane being new, during the initial years considerable spade work had to be done in understanding the various factors involved. The remarkable results achieved within a short time has been, in no small measure, due to the meticulous planning, powers of observation and dedication shown by Venkataraman with only two assistants to help him. Observations on flowering of varieties, fertility of pollen, artificial culture of pollen, viability of hybrid seed etc. were carefully recorded and coded for use in the hybridisation programme. The station was the first to start induction of flowering in non flowering sugarcane varieties through photoperiodic treatments which has become so common these days. The complicated nature of inheritance in this polyploid, heterozygous crop compelled Venkataraman to discard the normal breeding methods of selfing and inbreeding in favour of outcrossing and obtain maximum variation. The results of this systematic research were outstanding. The first generation hybrids of the two species, *S. officinarum* × *S. spontaneum*, Co. 205 and Co. 285 (Co. for Coimbatore) became acceptable commercially in Punjab and replaced the low yielding indigenous varieties giving 50% more yield besides capable of being grown under stress conditions including waterlogging.

This initial success with two species crosses led Venkataraman to plan roping in a third species, *S. barberi*—the indigenous Indian species—indirectly and effect tri-species hybrids, one of which, Co. 244 was accepted as a commercial variety in Uttar Pradesh. Thus all the sugarcane varieties that emanated from the Coimbatore

Institute these years are the products of the three species, *S. officinarum, S. spontaneum* and *S. barberi* initially planned by Venkataraman. It is also a fact that the hybrid varieties evolved in some of the sugarcane breeding stations in the world have in them the parentage of Co. canes and thus the three species. Later a fourth species, *S. robustum* was added to the list of parents.

Venkataraman can be credited with evolving many original techniques relating to sugarcane breeding. One of them was very useful in eliminating contamination of crosses in the field by chance pollen at a time when bagging interfered seriously with seed setting. The technique consisted in isolation of sugarcane stalks through aerial rooting at the nodes using inexpensive tile pots and removing the rooted stalks to isolated sheds for controlled hybridisation away from foreign pollen. In his usual humorous way, Venkataraman styled these isolation sheds as "nuptial chambers" with the sugarcane arrows (panicle) of male and female varieties. This original method of rooting and isolation later led to the development of techniques in other countries for controlled crossing.

Taking advantage of certain cyto-genetical peculiarities in sugarcane conducive to wide crossability, Venkataraman, in 1930, attempted the wide inter-generic cross, sugarcane × sorghum with the specific purpose of evolving short duration (6 months) sugarcane varieties. The cross was a success (at Coimbatore and later in USA) and genuine hybrids were obtained. It is true that no commercially acceptable sugarcane varieties have emanated from this cross, partly because the work was not followed up in all seriousness and in a systematic manner due to sterility problems. It may not be inappropriate to point out here that, during the last two decades, short duration varieties in wheat, rice, pulses etc. have been emphasised by plant breeders. Venkataraman conceived this idea of short duration varieties in the very long duration sugarcane crop over half a century ago. Sugarcane × maize cross was also effected during his tenure of office by Dr Janaki Ammal and one seedling, a genuine hybrid based on cytological studies is still available at the Institute.

Encouraged by the success of the sorghum hybridization programme (even if academic), Venkataraman planned a still wider inter-generic cross between sugarcane and bamboo, to introduce, if possible, the vigour and hardiness in sugarcane varieties which raised many eyebrows among plant breeders and geneticists. The idea of utilizing bamboo (*Bambusa arundinacea*) came to him during his daily walk along the bamboo grove planted as a fence along the southern border of the campus. The cross was effected in 1936 using male sterile sugarcane varieties as pistil parents and dusting bamboo pollen done under controlled conditions. Seedlings were obtained and there was excitement throughout the plant breeding world. Venkataraman was invited for the International Genetics Congress held at Edinburgh in 1939 and presented the details. The Daily Herald of London described him as "the man who fooled nature and put sweetness in India". It is true some of the seedlings showed characters normally found in the bamboo species. Later, detailed studies revealed that the seedlings resulting from the cross (no doubt under controlled conditions using male sterile varieties) may have been the result of parthenogenesis, a factor overlooked with limited knowledge on the subject. Further work by later scientists has shown that bamboo pollen germinates on sugarcane stigma and normal fertilization takes place. However, at the eight-celled stage of the embryo, the endosperm gets separated from the embryo—a case of somatoplastic sterility—and it perishes for want of nutrition. With our current knowledge of embryo and tissue cultures, it should be possible to nurture the embryo under artificial conditions. Venkataraman has thus sown the seed for such revolutionary research and today we hear of crosses involving wheat and barley, potato and tomato and so on. Venkataraman was a revolutionary scientist and thinker—" One man and one intellect—a host in itself".

The impact of Venkataraman's sustained research on sugarcane breeding and evolving improved varieties has to be judged by the progress on the Indian Sugarcane Industry during the last fifty years. If from an importing country in 1930 India today is not only self sufficient in white sugar but can also export sugar, it is due to the impact of the Co. varieties bred by Venkataraman which heralded the dawn of prosperity for the Indian sugarcane grower. Starting with the release of Co. 205 in the twenties, which along with Co. 285 replaced the indigenous varieties in the Punjab (undivided) with increased productivity, there was a spate of further and greater improvements with varieties suited to almost all soil and climatic conditions, particularly in the subtropical belt. Later the cosmopolitan variety Co. 213 served the industry in Uttar Pradesh, the major cane growing state for a number of years followed by the versatile Co. 312 suited admirably to both the white sugar and gur (jaggery) industries. Co. 313, an early variety did very well in Bihar. Co. 453, a late high yielding variety was popular in Bihar and UP and so also Co. 421 and Co. 527. Co. 419 became universally popular in all the states in tropical India and sustained the industry for four decades as the wonder cane. Such was the merit and popularity of the Co. varieties bred by Venkataraman and his associates that within a decade the indigenous varieties were almost completely replaced with increased yield per unit area and recovery. No wonder, in some quarters it was said in a humourous vein that Venkataraman has done a disservice to the Indian sugarcane industry by his famous Co. varieties since these suited a wide range on soil and climatic conditions and introduced a sense of complacency and laziness in the farming community for improving productivity through human efforts and agronomic practices. The stupendous growth of the sugar industry during the last 50 years in terms of area under sugarcane, yield per unit area, recovery etc. is well known. From a production of one lakh tonnes of sugar in 1930, we now clear around 70 lakhs on an average. The 30 factories in 1930 have multiplied ten times. All this has to be attributed to the impact of the hybrid Co. varieties evolved at the Coimbatore Institute with the hard work done and secure foundation laid during the earlier years by Venkataraman and his associates.

The diverse conditions in the country for which the Co. varieties were bred could not but have its implications worldwide. The Co. varieties were sought after by other sugarcane growing countries. Co. 281 became the main variety in the Louisiana belt of USA as also Co. 290. In Cuba Co. 281 became very popular as one well suited to indifferent conditions. Its high tonnage on poor dry lands and high sucrose content and early maturity is bringing it more and more to the front as the best cane with which to replace Crystalina on lands where there is failure from soil exhaustion and lack of fertility.

Science knows no political boundaries. How the Co. Variety Co. 281 saved the South African Sugar Industry from ruin during the thirties is interesting to recall. The indigenous low yielding variety *Uba* was threatened with extinction. The variety Co. 281, sent on request, not only replaced it but also sustained the sugar industry of South Africa. Later, another variety, Co. 301, occupied large area in the country. Still later N. Co. 310, the outcome of hybrid seed sent from Coimbatore, occupied the largest commercial area in the world for any sugarcane variety, being popular in many countries besides South Africa. As a mark of appreciation, the South African Sugar Technologists Association gifted to the sugarcane Breeding Institute during the period of Venkataraman a wax model of sugarcane wax of Co. 281 and *Uba* stalks, each stalk four feet with leaves and absolutely realistic which now adorns the museum of the Institute. What more tribute can be showered on a scientist and an Institute than that the South African Sugar Technologists Association elected Venkataraman as an Honorary Fellow and Dr H H Dodds, the then President and Director of the South African Sugarcane Experiment Station wrote to Venkataraman: "This, I believe is the first occasion in which any one living away from South Africa has been elected to honorary membership and is some indication of the very great appreciation felt in the sugarcane industry here of your work in introducing new varieties of sugarcane that have been so valuable to us. The only serious complaint about these new varieties that have so far outstripped our old *Uba* cane is that they have tended to bring out *acute state of overproduction of cane* that now exists". In Australia, Co. 290 became popular and in the British West Indies—Barbados, Trinidad, British Guiana—Co. 419 became the mainstay with the growers, with Co. 421 also being grown. At one stage during 1960s, the Coimbatore varieties were under commercial cultivation in 22 countries in the world and sustaining their sugar industry. While the monumental study of Barber on the morphological descriptions and classification of the Indian canes is regarded as a 'classic', Venkataraman ably followed it up by the description of the Co. varieties to aid in their identification and avoid varietal mixtures.

Venkataraman was assisted in his work during the earlier years by P Thomas, a non-matriculate but with a high degree of common sense and practicality in his vision and approach. He stood by Venkataraman and was gifted with the title 'Rao Sahib'. From 1926 when the breeding work for tropical India was started, N L Dutt was next in command to Venkataraman and ably supported him. He is to be considered the architect of the varieties Co 419, Co 421 and Co 453. Co 419 was hailed as the wonder variety for the tropics and served the entire sugar industry below the Vindhyas for well over four decades; Dutt succeeded Venkataraman when he retired on superannuation in 1942.

Publicity being one of the keynotes to success, Venkataraman was not lacking in it. He rightly fitted the adage 'The pen is mightier than the sword'. With a flair for writing and excellent command of English and capability of suttle humour, the forty and odd scientific publications in various journals give a insight into his love of science, industry in collection of facts, large share of common sense and unbounded patience. The museum room at the Station depicted in a non-scientific manner the mythological origin of sugarcane, India anxiously awaiting sugar supply from Java, the family tree of a Co. hybrid with human figures to indicate the male and female parents, the breeding techniques, the progress of the sugar industry and so on in a style which was self explanatory and easily followed by a layman.

HONOURS AND AWARDS

Right from the start of his career, Venkataraman had shone as a brilliant scientist with keen powers of observation, independent and original thinking, meticulous planning and sincere and dedicated work. No wonder, honours were showered on him right from the early days, both from the scientific side and the administrative (government) side.

Venkataraman presided over the agricultural section of the Indian Science Congress in 1928 when the theme of his address was on 'Indian Sugar Bowl'. In 1929, he visited Java to attend the meetings of the International Society of Sugarcane Technologists and presided over the varietal section. In 1932, he was appointed to the Indian Agricultural Service (IAS then) of the Government of India.

Venkataraman was elected General President of the 1937 Indian Science Congress when he delivered the presidential address 'The Indian Village' interpreting the village to the urban scientists. The problems in the villages with over population of men and cattle, fragmentation of holdings, dependence on monsoon for agriculture, lack of amenities like schools, hospitals, transport etc. were vividly brought out in the address and his final conclusion was clear : "Our duty then is clear, namely, to improve the village, the nucleus of our country life and inject its chief agent, the villager with a chosen culture of the virus of modern age through education and industrialisation". Pre-independence thoughts ! For the second time, Venkataraman was President of the agricultural section of the Indian Science Congress in 1938 when he spoke on 'Hybridisation in and within the genus *Saccharum*. Venkataraman was hailed as the wizard of sugarcane when he attended the 1939 International Genetics Congress at Edinburgh. The Indian Society of Genetics and Plant Breeding had the honour of having him as President for a term. The Andhra University awarded the honorary degree of Doctor of Science (DSc) to Venkataraman.

In 1956, when the International Society of Sugarcane Technologists held its meetings in India, Venkataraman who had retired chaired the cane breeding section. On the occasion, a plaque on the birth of the first commercial hybrid variety Co. 205 (his baby) was unveiled at the Sugarcane Breeding Institute, Coimbatore at the exact place where it was born.

On the Government side, when the first hybrid variety, Co. 205 replaced the indigenous varieties with higher yield, the title of 'Rao Sahib' was conferred on him in 1920. After the Viceroy Lord Irwin's visit to the Station in 1927, Venkataraman was awarded the title of 'Rao Bahadur' in 1928. The work on sugar cane × sorghum hybridisation got him the title of *IE* in 1937. To crown all glory, after his work on sugarcane × bamboo crosses, Venkataraman was knighted (the conferment of the title 'Sir') in 1942, the first ever agricultural scientist in the country to be honoured by the British Government. In 1956, the Government of India honoured Venkataraman with the title of 'Padma Bhushan' at the time of the International sugarcane Congress meetings, many years after his retirement.

In 1962, when the Golden Jubilee of the Sugarcane Breeding Institute, Coimbatore was celebrated, the South Indian Sugar Mills Association presented to the Institute a portrait painting of Venkataraman (for which he personally and patiently gave a few sittings) who brought so much name and fame to the Institute internationally. The portrait now adorns the walls of the library room at the Institute.

FAMILY, RETIRED LIFE AND LAST DAYS

Sir T S Venkataraman retired from service as Sugarcane Expert to the Government of India in 1942 after 35 years of dedicated service to the cause of sugarcane research and being given an extension of three years service. He settled down for a while in Coimbatore when he agreed to undertake a survey of sugarcane research in the country. He gave up the assignment on health grounds and settled finally in Madras spending his time reading the Gita, Upanishads etc. He was a frequent writer in the Hindu newspaper 'Letters to the Editor' on diverse subjects from Gita to family planning and birth control. Happily married, Mrs Venkataraman was a deeply orthodox and religious lady shunning publicity and content to be a good housewife. Their only son, V Ramamurthy retired as Assistant Director, National Physical Laboratory, New Delhi.

Sir T S Venkataraman passed away in January, 1963 at Madras, secure in the knowledge that his place in the history of science is assured. Recapitulating the chief factors that have contributed to the success of the Coimbatore work, Venkataraman mentions "(a) the pointed attention paid to the work by every worker at the station, enforced by the temporary nature of the Station with its life extended for very short periods each time; (b) the almost ascetic mind which enabled them to force into service whatever facilities, including apparatus, available at the time instead of waiting for some unit to be received from outside the country : (c) the unorthodox methods adopted including such wide hybridisation as intergeneric and inter-racial (to use a popular term) and (d) last by no means least, the researchers going to their work without looking at the clock resulting from the lively enthusiasm for the work set before them and the ultimate aim of the work viz. to win back to the country its ancient position in the sugarcane world". Today India is the largest producer of sugarcane and sugar in the world—a tribute to the above prophetic statement of Venkataraman and he did live to see his prophesy and dream come true.

Swift in Gulliver's Travels says "Whoever could make two cobs of corn or two blades of grass grow where only one grew before would, deserve better of mankind and do more essential service to his country than the whole race of politicians put together". Truly, Sir Venkataraman made two and often more stalks of sugarcane grow where one or none grew before and is, thus, entitled to the everlasting gratitude of this country. He is entitled to be remembered by every one who adds a spoon of sugar/gur to his daily cup of coffee/tea in the morning, as the author of the sugar revolution which came three decades ahead of the green revolution.

ACKNOWLEDGEMENTS

The author has the unique privilege of being the only student of T S Venkataraman, for MSc degree since the latter did not believe in taking students for post-graduate degrees. It was a sheer good fortune that the author was enlisted as a student during the extension years of service of the scientist. With forty years (1939-79) at the Sugarcane Breeding Institute, Coimbatore, the author feels honoured to write this biographical sketch of the wizard of sugarcane breeding. In the words of Isaac Newton : "If I have seen further, it is by standing on the shoulders of giants".

In writing this biography, the author has drawn freely from the publication of the Sugar Technologists Association of India (STA—1944) entitled. 'Sir T S Venkataraman—the Scientist and the Man'—based on the personal discussions of Mr P N Nayar of the Association with Venkataraman.

The author is thankful to the Director, Sugarcane Breeding Institute, Coimbatore for providing the library facilities and the photograph of T S Venkataraman).

J Thuljaram Rao

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SRINIVASA RAMANUJAM

(1903–1979)

Elected Fellow 1948

BIRTH AND EDUCATION

SRINIVASA RAMANUJAM was born on October 2, 1903 at Vanavasi near Salem, (Tamil Nadu). He was the son of Shri K Srinivasa Iyengar, the local Village Munsiff. They were four brothers and five sisters. Ramanujam had his early schooling in Salem and Madras. He then joined the Presidency College, Madras, for his Botany Honours under the distinguished algalogist, Professor M O P Iyengar. He took his honours degree in Botany and Geology in 1925 and was awarded the MA degree of the Madras University in 1927. Though conservatism of his parents prevented his joining the Indian Forest Service for which he was selected, he later proceeded in 1935 to King's College, London, to work with Professor Ruggles Gates, FRS, and obtained his PhD from the London University in 1937

PROFESSIONAL CAREER

Dr Ramanujam began his professional career as a Research Assistant to the Paddy Specialist at Coimbatore. From 1938-1946, he worked as the Second Economic Botanist at the Indian Agricultural Research Institute, New Delhi, From 1946-1956, (except for one year), he was the Director, Central Potato Research Institute, in the establishment of which he played a leading and important role. Later, he was posted as Director of Research, Department of Agriculture, Government of Bihar, where he organized and guided all aspects of agricultural research in the state till 1966. After retirement, he settled down in Bangalore. Even in his retirement his expertise was much sought after and he continued to be associated with several expert committees of ICAR, INSA, Government of Bihar and the University of Agricultural Science, Bangalore.

SCIENTIFIC CONTRIBUTIONS

Dr Ramanujam was one among the earliest scientists in India to initiate cytological studies under the overall leadership of Dr K Ramiah, the then Paddy Specialist, Coimbatore. Dr Ramanujam, in close and equal collaboration with his colleague, Dr N Parthasarathy, FNA, made significant contributions to the cytology

S. Ramanujam

of rice. For the first time, haploids, triploids and tetraploids were identified in rice, their cytological and breeding behaviour studied and their utility in crop improvement evaluated. The finding that twin/polyembryonic seedlings could be of different ploidy levels was an important contribution. This group also initiated mutation breeding in rice using X-rays; they identified ring formation as a result of translocation, chlorophyll deficiency and asynaptic plants in the mutagenised material.

Dr Ramanujam carried out in London his PhD work on rice, the results of which were incorporated in three papers. In particular, he studied the cytological behaviour of an interspecific hybrid, *Oryza sativa* × *Oryza officinalis* and the progeny, including triploids and aneuploids ($2n + 1 — 2n + 5$) derived therefrom and elucidated the interrelationship between the two species.

On joining the Indian Agricultural Research Institute in 1938, Dr Ramanujam took up the systematic exploitation of colchiploidy induction announced by Blakeslee and Avery in the previous year (1937). Polyploids of a large number of crop plants were induced by him and his colleagues and students; the autopolyploids thus produced were cytologically analysed, their breeding behaviour followed and utility assessed. Most fruitful was the pursuit of induced amphidiploidy, obtained by colchicine treatment of interspecific crosses in different genera. In these amphidiploids, fertility was generally restored. By a detailed study of the amphidiploids obtained from the interspecific cross, *Brassica campestris* × *B. nigra,* his group was able to elucidate the origin of the natually occurring taxon, *Brassica juncea,* a widely cultivated oilseed crop of India. From the interspecific cross in *Sesamum,* (*Sesamum orientale* × *S. prostratum*), an entirely different plant, created as a new species, *Sesamum indicatum*, was obtained; this amphidiploid proved useful in the transfer of disease-resistance from the wild *prostratum* to the cultivated oilseed, *S. orientale.*

Dr Ramanujam as the first Director, was responsible for organizing the Central Potato Research Institute, guiding it at its formative stage and putting research on potato in India on a strong foundation. Under his able guidance, the institute contributed strongly to the betterment of the potato crop in India, through the development of improved varieties and improved management practices. After thorough screening of a large number of true seedlings obtained through hybridization, several improved varieties of potato suitable for cultivation in the plains and hills of northern India were developed. An important idea developed by him of stabilizing workable homogeneity in populations raised from true seed to provide the commercial crop, is now being extensively pursued as an answer to disease degeneration problem attendant on tuber reproduction. The results of the researches carried out by Dr Ramanujam and students under his guidance have been incorporated in a number of papers published in leading scientific journals.

Dr Ramanujam was invited by the Bihar Government to help implement their decision to revamp agricultural research in that state. In the ten year period between 1956-66, Dr Ramanujam devoted himself to planning, coordinating and developing agricultural research in the State of Bihar, so full of unrealised-potentialities for agricultural production. He initiated and supervised the setting up of four Regional

Research Institutes, encouraging multidisciplinary research. Special mention may be made of his emphasis on comprehensive studies on the acid soils which cover a large portion of the state. Dr Ramanujam was able to bring about a marked improvement in the tone and tempo of research which contributed to an all-round improvement in the agriculture of Bihar. Improved varieties were evolved, new crop protection methods discovered and measures for increasing soil productivity developed.

HONOURS

Dr Ramanujam has been honoured by several learned societies by being elected as a Member/Fellow. He was a Member of the Genetical Society of Great Britain and of the British Association for the Advancement of Science. He became a Fellow of Indian National Science Academy in 1948. He was elected President of the Botany Section of the Indian Science Congress in 1952. He was a Founder-Member of the Indian Society of Genetics and Plant Breeding and helped to spread the ideals of the Society which he served in several capacities including as Secretary and President.

FAMILY LIFE

Srinivasa Ramanujam married Vedam, daughter of Sundararaja Iyengar in 1933. His eldest daughter Manjula, is married to Shri P Srinivasan, presently Commissioner of Income-tax, Delhi. His second daughter, Hema, is married to Shri S R Ramakrishnan, now Joint Director, Steel Authority of India. His eldest son, late R Srinivasan, was professor of Physics at the Indian Institute of Science, Bangalore, while his second son, R S Rajan, is working as Project Engineer, Occidental Petroleum, Florida (USA).

Dr Ramanujam suffered a stroke on 9 June 1979 and passed away on the same day at Bangalore leaving behind his wife, two sons, two daughters and a host of students and colleagues to mourn his loss.

N PARTHASARATHY

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HARENDRA NATH RAY

(1899–1969)

Elected Fellow 1950

EARLY LIFE AND EDUCATION

HARENDRA NATH RAY was born on January 31, 1899 in Meerut, Uttar Pradesh, as the fifth child of Dr Haricharan Ray and Shrimati Swarnamoyee Devi. His father Dr Haricharan Ray was a successful medical practioner in Meerut who had to take special paternal care in upbringing his fifth son, H N Ray because he lost his wife Swarnamoyee when his son was hardly four years old. Young Ray had his school and college education upto the stage of the Intermediate of Science (ISc) in Meerut where he proved to be an average student. He then moved to Calcutta to study the BSc Honours course in Zoology in the University of Calcutta. Then afterwards there was a remarkable change in his education career. He obtained his BSc degree in 1922 with Honours in Zoology securing first class first position and received the Calcutta University Jubilee Scholarship for his merit. He continued his MSc studies in Zoology at University of Calcutta and duly passed the Examinations in 1924 securing the first class first position again. He received the Calcutta University gold medal and the general proficiency prizes for his meritorious MSc result.

RESEARCH CAREER

After his MSc, he joined the University of Calcutta as a member of the faculty in the Department of Zoology where he came under the influence of Late Rai Bahadur Dr G C Chatterjee, Professor of Parasitology, Calcutta Medical College. At this stage, Ray had his early initiation and training in protozoological researches and subsequently devoted his whole life on parasitological researches (protozoology in particular). At the beginning of research career the University of Calcutta awarded him, in 1926, with the Premchand Roychand Studentship (PRS) on the merit of his dissertation on the study of flagellates in vertebrates for carrying out further researches in the said field and finally he was awarded the Mouat Gold Medal by the University of Calcutta after adjudicating complete research works. In 1927, as the Guruprasanna Ghosh Scholar of the University of Calcutta, he left India to undertake his doctoral research work in protozoology under Professor Doris L Mackinnon in the Department of Zoology, King's College, University of London. In 1930, he was awarded PhD by the University of London. His research work was acclaimed by the noted protozoologist of the time Mr Clifford Dobell, FRS and others. During his stay at the King's College he received the financial support from Layton Research Grant to carry out his doctoral research.

After obtaining the PhD degree, Dr Ray returned to India and continued to serve the University of Calcutta first as an Assistant Lecturer and then a Lecturer in Zoology. In 1936, he left the teaching job of the University of Calcutta and joined the Indian Veterinary Research Institute, Mukteswar UP as Research Officer and in-charge of protozoological research. Later, he became the Head of the Parasitology Division of IVRI, Mukteswar, Kumaun Hills and Izatnagar, UP. He retired in that position from the IVRI in 1954. After his retirement from the IVRI, he joined the Calcutta School of Tropical Medicine as the Professor of Protozoology. In 1956, as a recognition of his outstanding researches in parasitology, he was awarded the Joygobinda Law Memorial Medal by the Asiatic Society, Calcutta. Dr Ray continued to serve the School of Tropical Medicine as Emeritus Professor of Protozoology after his superannuation. His age was never a bar to his undaunted spirit of conducting researches. In 1965, he shifted his research activities from the Calcutta School of Tropical Medicine to the Department of Zoology, Presidency College, Calcutta as a Retired Scientist of the Indian Council of Agricultural Research and later as an Emeritus Scientist, Indian Council of Medical Research and a Retired Scientist of the Council of Scientific and Industrial Research.

RESEARCH CONTRIBUTION

The research works of Professor Ray on parasitic protozoa gave him worldwide recognition. He created a number of new genera and species in Rhizopoda. Mastigophora, Cilliophora, Gregarina, Coccidia and Haemosporidia. He started as a classical protozoologist and carried out systematics and bionomics of a good number of parasitic protozoa in odd types of host. He discovered several sporozoan species in polychaete worms, millipedes, and with his guide Dr D L Mackinnon, intestinal amoeba of an ascidian, a coccidian form in the eggs of *Thalesemma neptuni* etc. He named many new species specially of Coccidia and Gregarina from various vertebrate and invertebrate hosts and did some classical studies on these protozoa. He developed the stilbamidine test for the detection of the latent trypanosomal infection in Zebu cattle and buffaloes and even in camels which has been acclaimed of very high applied value. Thus, after his joining the Indian Veterinary Research Institute and later, he did a great deal of work on trypanosomes, *Leishmania* and other flagellates, on *Entamoeba* and other intestinal amoebae, on malarial parasites of birds and mammals and other parasites of man and domestic and wild animals which earned him the world recognition. He did pioneering work to establish the mode of transmission of *Theileria annulata* in cattle through the eggs of infected ticks, *Hyaloma savignyi*. His discovery of the presence of the clusters of small cysts in the liver of the Himalayan giant flying squirrels at Mukhteswar in Kumaun Hills depicting the exoerythrocytic schizogony of a malarial parasite referred to as a new genus *Rayella* was a very fundamental nature which acclaimed him a checkered credit. Incidentally, when the world is fully aware of the outstanding discovery made by Sir Ronald Ross in the Calcutta School of Tropical Medicine on the role of female anophiles mosquitoes in the transmission of human malaria, we were practically unaware of another discovery made by Professor H N Ray, working in a remote place in the foot-hill of the Himalayas, on the life-cycle of a non-human malarial parasite. The tissue stages of the malarial parasite were discovered in the thirties but unfortunately he published in brief only in 1949 (Ray H N 1949. *Proc natn. Inst. Sci.,* India, **15**, 241-242), two years after the discovery of the tissue stage of another malarial parasite in the African monkey made by Professor P C C Garnham (*Trans. Roy. Soc Trop. Med. Hyg.* 1947, **40**, 719-722). In fact, Professor Ray came across stages of the malarial parasite in the blood of its host, the Himalayan flying squirrels (*Petaaurista inornata*) at Mukteswar during 1937–1948). He, however, found no evidence of the multiplication of the parasite in the red blood corpuscles of the infected animals. Their liver, lung, and spleen, however, showed, some uncommon pinkish areas. In the histological sections of the spleen, these areas revealed two different forms of the parasite undergoing multiplications. He could realize the importance of his findings of two forms of the parasite in liver and spleen of the infected flying squirrel only after he came across with Professor Garnhams discovery of similar stages occurring in the African monkey. Thus, he lost the race on the principle of priority. The real fact would be clear from the book on *Malaria Parasites and their* Haemosporidia by P C C Garnham (published by M/s Blackwell, Oxford, 1966) where he acknowledged that Professor H N Ray first encountered and studied the malarial parasite in the Himalayan flying squirrels in 1937. The full account of the parasite, without being able to assign the genus and species, was published by Ray in 1960 only (*Proc. natn. Inst. Sci. India* **26B**, Suppl., 1–5). It was left to Tokura and Wu of Japan to name the parasite as *Hepatocysticis rayi* from the giant flying squirrel of Formosa (*Petaaurista grandis*). (Tokura N *and* Wu chen-lan 1961. *Endem. Dis. Bull. Nagasaki University*, **3**, 174–179) thereby acknowledging the original discovery of Dr Ray by naming the species in his name. Though Professor Ray was primarily interested in the morphotaxonomy of different groups of Protozoa but in the later part around 1960s, he became interested in the cytochemical studies of protozoa along with his original line of investigations. All through his life he concentrated his research activities on the parasitic protozoa in particular because of his initial training and later the influence of joining the Indian Veterinary Institute and the Calcutta School of Tropical Medicine. Dr Ray was a rare type of devoted research worker who was in the midst of research activity even two days before his death on May 30, 1969. His research works are quoted in many standard books on protozoology to make his name immortal.

Professor Ray gave a good leadership in the protozoological researches in India. Many established Indian protozoologists like Dr M M Chakraborty, Dr B S Gill, Professor B Das Gupta, Dr B N Singh and others were associated with Professor Ray as collaborators while about half-a-dozen students received their PhD degrees of the University of Calcutta working under his guidance. Professor Ray was hard task master and at the same time very inspiring to the younger students of the time as well as to his elderly collaborators as he used to see their works and discussed them very earnestly.

MEMBERSHIP OF SOCIETIES AND HONOURS

Professor Ray was not only an untiring research worker but also a good organizer. Unfortunately his keen desire of establishing the Indian Society of Parasitology came into the existence posthumously in 1977 but the said Society remembered him in most befitting manner in publishing an authentic biographical sketch of him in the first page of the very first issue of the Indian Journal of Parasitology. Professor Ray was actively associated with the Zoological Society of India being its Foundation Fellow. He was also a Foundation Member and later was elected as its President for a period of the Zoological Society (Calcutta). He was a Member of the Asiatic Society, Calcutta. He was Honorary Life Member of the Society of Protozoologists, USA, and a Member of the Indian Science Congress Association. In appreciation of the research contributions of Professor H N Ray, he was elected Fellow of the Royal Society of Tropical Medicine and Hygiene, Fellow of the American Society of Parasitologists, and Fellow of the Indian National Science Academy in 1950. He served for one term as a Member of the Sectional Committee of the Academy.

Professor H N Ray delivered lectures in various research institutes and universities of our country and chaired in seminars and symposia. He was elected President of the Section of Zoology and Entomology at the 32nd session of the Indian Science Congress. Professor Ray also visited various universities and research institutes in USA on a lecture tour organized jointly by the American Society of Parasitologists and the American Institute of Biological Sciences in 1962. He lectured at the University of California (Los Angeles), Utah State University, Louisiana State University, Tulane University, Rutgers University, Illinois University and Minnesota University. He participated the Annual Midwestern Conference of Parasitologists at the University of Nebraska and delivered a special lecture at the annual meeting of the American Society of Parasitologists at Washington DC. He was elected the Sectional President in the Third International Congress of Protozoology in Leningrad in July 1979 but his premature death did not allow him to participate in the Congress.

PERSONAL LIFE

Though Professor Ray was an ardent research worker, it did not turn him unsocial in the least. He had a very good sense of humour and could keep his company amused in jokes when he was free. He could sing songs in Bengali and in Hindi though not a master singer. He was religious minded and a devotee. Professor Ray had a peaceful family life. He was married in 1919 to Shrimati Shantimoyee Devi daughter of Rai-Bahadur S N Sen of Indian Mirror. He was blessed with three children, of whom Dr Dipak Ray followed his father in carrying out parasitological research. Professor Ray died of a heart ailment on May 30, 1969 at the age of 70.

G K Manna

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PONANI NARAYANA GANAPATI

(1910–1984)

Elected Fellow 1961

EARLY LIFE AND EDUCATION

PONANI NARAYANA GANAPATI was born in a middle class Hindu family on July 15, 1910 at Manjeri in Kerala State to Srimati Anantalakshmi and Shri P G Narayana Iyer. Shri Iyer was employed in the Revenue Department of Kerala State till retirement.

Ganapati had his primary schooling at the Board Middle School, Manjeri (1915-1920) and completed his secondary education at the Santa Cruz High School, Cochin and Sircar High School, Ernakulam (1921-27). These missionary institutions instilled in him a sense of strong discipline from his early age. In the high school, he took active interest in games and was considered a good badminton player.

Young Ponani obtained his BA from the Maharaja's College, Ernakulam in 1931. He passed his Intermediate examination with Natural Sciences, Physics and Chemistry and majored in Zoology, with Botany as subsidiary for the BA. He obtained the first rank in the University of Madras for the BA Degree Examination in the Natural Science subjects and was awarded the "Sealy Memorial Prize". He joined the Presidency College, Madras for the Post-Graduate Course leading to the MA Degree in Zoology in 1932 and obtained the Degree in 1934. In 1935, he joined the Zoological Research Laboratory, University of Madras as a research scholar under the guidance of late Professor Gopala Ayyar. He took his PhD and DSc. degrees from the University of Madras in 1938 and 1942 respectively based on original research work and thesis on "Studies on Parasitic Protozoa and Polychaete worms". He had his Post-doctoral research training at the Molteno Institute of Biology and Parasitology, University of Cambridge, England for two years (1947–49) under the supervision of Professor D Keilin, FRS, and Professor P Tate.

PROFESSIONAL CAREER

In 1934, he was appointed as Demonstrator in Zoology at the Presidency College, Madras and in 1959, he was inducted as Lecturer in Zoology at Madras Christian College, Tambaram where he served for two years. During 1942-45, soon after getting DSc in Parasitology, he joined the Defence Services at Aurangabad as Antimalaria Officer. After returning from UK in 1949, he worked as a Research

P. Y. Ganapati.

Officer for a few months at Central Marine Fisheries Institute, Madras. In the later part of the same year, he joined as a Reader in Zoology, Andhra University, Waltair, and continued in this post till 1953. During this period, he organized both teaching and research programmes in parasitology in the department. In 1954, he was elevated to professorship and was appointed as the Head of the Department of Zoology to succeed the earlier distinguished personality, Professor R Gopala Ayyar. With his knowledge and research experience in several areas of zoology, he became an asset to the university. Taking advantage of the location of Andhra University on the east coast and with his earlier experience in marine fisheries at Madras, he quickly expanded his research activities to the field of marine biology in addition to parasitology.

He was the chief architect in building up the Zoology Department of Andhra University as a leading centre in India, with a good reputation for high quality of training and excellence in research. He built an excellent zoological museum in the Zoology Department, which attracted students from various colleges in Andhra Pradesh. He successfully developed the department into a well integrated unit of all aspects of zoology.

At the Andhra University, he served throughout as a Member of Academic Council and Senate. He was also Member of Board of Studies for Zoology in several Indian universities. He discharged his duties ably in all these capacities without allowing them to interfere with his teaching and research.

He retired as Professor and Head of the Department of Zoology in 1970. In recognition of his meritorious service, the University appointed him as Emeritus Professor, a position he held till his last day. The University of Berhampur appointed him as a Visiting Professor for a period of two years (1978-79) where he organized and built a new Department of Marine Sciences. He kept himself active till the very end.

CONTRIBUTIONS TO SCIENCE

His main contributions are in the field of parasitology and marine biology. In parasitology, he was the first to describe the life histories of several new sporozoans causing disease to the food fishes of India. These works have often been quoted in recognized text books of protozoology. In marine biology, he had trained several students in biological oceanography, zooplankton, phytoplankton and estuarine hydrobiology. His studies alongwith his students on the hydrobiology of the Godavari estuarine systems have contributed much to the understanding of the fauna of the estuary with special reference to fish production. In recognition of this work, the Indian Council of Agricultural Research had sanctioned a major project on "The Hydrobiology and Faunistic Survey of the Godavari Estuarine Systems" for a period of seven years (1958-64) under his leadership. He was looked upon as an outstanding authority of estuarine biology in the country. In addition, he was the pioneer to start the productivity studies of marine waters in India as well as the biological studies of marine borers and foulers which play a vital part in marine biodeterioration. He had also initiated for the first time, studies on the physiology of marine animals in India with special reference to barnacles, molluscs and crustaceans.

Intertidal Ecology Interstitial Fauna

Pioneering work on the systematics and ecology of littoral fauna was carried out at Visakhapatnam and Kakinada, under the guidance of Professor Ganapati. The investigations covering different groups established the existence of a rich and varied littoral fauna in the region. Species new to science have been discovered and accurately described among bryozoa, mollusca, polychaeta, nematoda, gastrotricha, kinorhyncha, copepoda, and echinodermata. A large number of new records to Indian waters have been made and the known range of several species extended. Ecological and biological studies were made on a number of littoral species, furthering our knowledge on the life in this biotope.

Some important results obtained through different investigations are briefly presented below :

Bottom Fauna at Godavri Estuary and Visakhapatnam

85 species of polychaets (excluding serpulids), 115 species of gastropods, 57 species of pelecypods, and 9 species of echinoids were identified and listed from the Godavari estuary area and Visakhapatnam. The distribution of the bottom fauna in relation to the substratum and other factors was studied and different faunal zones were demarcated.

Biology and Ecology of Marine Fouling and Wood Boring Organisms : Over 1000 species of marine fouling organisms and 22 species of wood borers were recorded from the Visakhapatnam Harbour and its vicinity. The anatomy, general biology and physiology of the pholad, *Martesia striata* as also some aspects of the biology of *Teredo furcifera* and *Bankia campanellata* were studied in detail. Settlement of biofouling organisms in relation to colour, texture, angle of immersion, currents, etc. were investigated and their seasonal abundance recorded. Natural durability of several species of Indian timbers and their durability after preservative treatment were evaluated.

The above investigations on marine biodeterioration, with considerable applied value, were carried out in collaboration with the Forest Research Institute, Government of India.

Interstitial Fauna : Comprehensive work on marine *interstitial* fauna inhabiting sandy beaches of Waltair coast was carried out. Representatives of Protozoa, Hydrozoa, Turbellaria, Nematoda, Gastrotricha, Kinorhyncha, Nemertina, Rotifera, Archiannelida, Polychaeta, Oligochaeta, Ostracoda, Copepoda, Isopoda, Tardigrada, Acarina, Collembola, Mollusca and Echinodermata were found inhibiting this interesting habitat. Several of the species listed are new records to Indian waters and some, new species. The influence of environmental factors in relation to the behaviour, density and distribution of the different groups of organisms were investigated.

Studies on Bryozoa : Bryozoa (Ectoprocta), a group that has long been neglected in both faunistic and ecological studies in the Indian Region, has been investigated in detail along the north Andhra coast. From the intertidal region itself, as many as 70 species were recorded. All the species listed are new locality records. One species is new to the Indian ocean, 17 species new to Indian waters and 4 species new to science. Quantitative distribution of bryozoa on the rocky coasts has been worked out and a distinct 'Bryozoan Band' has been incorporated in the tripartite zonation system at Visakhapatnam. Epizoic fauna, inter-relationships of bryozoa with other organisms, role of bryozoa in marine fouling, breeding seasons, etc. are some of the other aspects investigated. The study constitutes the most comprehensive work on littoral bryozoa in the region.

Brachyuran Fauna at Visakhapatnam : Detailed investigations on the brachyuran fauna at Visakhapatnam have been carried out. 33 species were identified and their early development observed. Of these, observations on 30 species are first records. The habits, method of feeding, stomach contents, maturity, sex ratio, etc., were studied for 13 species.

Phytal Fauna : Phytal fauna of 13 species of intertidal algae were studied at Visakhapatnam. A total of 235 species of animals belonging to 19 taxonomic groups and 27 species of epiphytic algae and diatoms were identified from the algae. The faunal characteristics of each alga (composition and abundance), distribution in relation to sediment factor, season, zonation, morphology of the alga, adaptation of phytal life are some of the aspects covered in their detailed study. These studies have also described the highly interesting bivalve gastropods (5 species) from the algae.

Marine pollution : Studies on the water quality and faunistic changes in the harbour and near-shore environments in relation to pollution at the industrial town of Visakhapatnam, were carried out. Polychaetous annelids were studied in detail. A total of 72 species were collected which exhibited characteristic response gradients in relation to water quality. Over the years, the harbour waters have become highly enriched leading to eutrophication. Five biological zones, based on faunal parameters were recognized in the harbour area. These are the azoic zone nearer to out falls, with no macroscopic life; polluted and semi-polluted zones with improvements in water quality and fauna : semi-healthy zone having more diverse life and healthy zone located in the unaffected open sea, supporting more normal life. These studies were carried out under a scheme sponsored by INSA.

Studies on Cellana radiata and Turbo intercostalis : Detailed investigations on the biology, ecology and physiology of the limpet, *Cellana radiata* and littoral snail, *Turbo intercostalis* were carried out. Growth rates, variations in shell characteristics in relation to the environment, population density, influence of temperature, salinity, dessication, larval development, reproductive cycles, etc., were worked out for these species.

Studies on Echinodermata : Taxonomic studies on Indian echinoids were carried out and 126 species described. The biology and ecology of the sea-urchin, *Stomopnestes variolaris* occurring on the rocky shores along the Visakhapatnam coasts was studied with major emphasis on its reproductive biology and digestive physiology.

Hydrography of the Godavari Estuary

Professor Ganapati's work on "Hydrobiological and Faunistic Survey of the Godavari Estuarine System" remains one of the most comprehensive works on an estuarine system in India. This work was mainly carried out under a project sponsored by ICAR.

The Godavari Estuarine system is highly extensive. Depth distribution and seasonal variations of hydrographic parameters were studied, in detail at Gautami, Godavari bay and Coringa river. These studies indicate (a) the occurrence of a major deep trough opposite Yanam and smaller troughs in Bhairavapalem and Kothapalem tributaries; (b) nearshore upwelling in April—May; (c) cellular type of circulation pattern; and (d) clockwise pattern of water movement from December-June and a counter clockwise pattern from July—November. The estuary does not rigidly confirm to any of the four types described by Stommel and Farmer through out the year. Instead, it exhibits the four types in the different seasons. The Corin a river system is characterised by extremely low transperancy values, thermal stratification followed by salinity stratification and high levels of nutrient concentration. These were the results of fresh water drainage from irrigational channels, and wash off from mangrove swamps.

Plankton and Productivity

Qualitative and quantitative investigations on plankton were carried out (mostly in the Bay of Bengal, off Waltair coast) and estimations of organic production made. The seasonal abundance of plankton organisms, their distribution in relation to salinity, temperature, transperancy, currents and depth have been investigated. A bimodel cycle coinciding with monsoons was noted for the phytoplankton. Of the 100 species noted, *Stephanopyxis palmeriana, Stereptotheca indica* and *Planktoniella sol* were identified as indicators of upwelling. The phytoplankton crop obtained off Waltair, during the south west monsoon was comparable to some of the highly productive waters in world.

Chaetognatha of the Indian coastal waters were studied in detail. Sixteen species were recorded and their seasonal distribution, abundance in relation to the prevailing hydrographical conditions were worked out. An inverse relationship was observed between turbidity and Chaetognatha occurrence. Swarms of the dinoflagellate, *Noctiluca* were found daterrent to the occurrence of Chaetognatha. Northerly current was found to carry a large number of chaetognaths to the Indian waters from Java and South Equatorial waters. *Sagitta sertatodentata* was noted to be good indicator of the oceanic waters.

Thirty three species and two varieties of pelagic tunicates were reported from the western part of the Bay of Bengal. Their seasonal distribution has been worked out and correlated with the water movement. It was found *Oikopleura intermedia, Fritellaria borealis F. sargasi, Thalia democratica,* etc. are useful indicators of water movement. Hydromedusae, polychaete larvae and amphipods occurring in plankton off Waltair coast have also been studied in detail.

Barnacle and Annelid Physiology

Respiration studies of the intertidal barnacles—*Balanus amphitrite communis, B. tintinnabulam* were carried out, in relation to body size, temperature, salinity, and oxygen concentrations. The study revealed a significant difference in oxygen consumption in relation to body size. Temperature coefficient, were studied using both Vant Haff's Q10 and the energy activation of Arrhenius. A study of the oxygen consumption in relation to different salinities showed a decreasing trend at low salinities unlike other Crustacea. Respiration in relation to oxygen concentration revealed that both the species are regulators. Post-anerobic oxygen consumption in *B. amphitrite communis* showed that they accumulate oxygen debt during anaerobiosis and the repayment of the debt was incomplete. An increase in temperature results in an increase of the respiratory movements. The respiratory movements did not show high ventilation to land oxygen concentrations.

Studies on the ecobiology and ecophysiology of marine/estuarine oligochaetes with special reference to *Pontodrillus bermudensis* were carried out. Tolerance studies to environmental parameters (salinity, temperature, pollutants, etc.) were made for *P. bermudensis,* enchytraeids and tubificids. Investigations on *P. bermudensis* proved that the adaptations of oligochaetes to brackish water is similar to that of a number of estuarine nereids in their osmotic regulations, isoosmotic intracellular regulations and respiratory mechanism. Marine tubificids were found to be indi- cators of organic pollution at Visakhapatnam harbour.

Physiological studies were also made on the sipunculid, *Sipuncula australae* for the first time form brackish water environments.

Fish and Fisheries

Investigations on fish and fisheries along north Andhra coast in general and Waltair coast in particular were initiated as early as 1954. Bionomics of clupeids, of which *Sardinell gibbosa* and *S. finbriata* are the most important, were investigated. Post larvae and juveniles of *Scomboromerus lancolatus* were described. Eggs, larvae and juvenils of 28 species of commercially important fish off Waltair coast were studied in detail. The distribution of fish eggs and larvae in relation to distance from the shore and salinity has been worked out. In recent years, a study was made to relate basic plankton and benthos production in the shelf waters to fish production, an important step useful in forecasting fish production. Prawn fishery in Godavari estuarine system has been studied. 43 species have been identified and their seasonal distribution, and responses to varying environmental factors were worked out. The biology of *Penaeus monodon* and *Palaemon tenuites* was investigated in detail.

Thirty six students took their MSc degree (by research), ten their DSc degrees and nineteen their PhD degrees under his supervision. Many of them have occupied or are holding positions of distinction in India and abroad. He had published 148 papers in Indian and international journal of repute covering a wide range of subjects like protozoology, marine biology, biological oceanography and estuarine biology.

HONOURS

During his eventful career as a scientist and teacher for over 30 years, many honours and distinctions were conferred on him. The Zoological Society of India awarded him Sir Dorabji Tata Memorial Gold Medal (1976) for distinguished contribution in zoology. He was elected as a member from India on the UNESCO International Advisory Committee on Marine science and attended the Oceanographic Congress held at New York in 1959. He also visited several institutions in USA and came into contact with distinguished scientists like Professor J D Costlow.

Under the Indo-Polish Cultural Exchange Programme, he toured Poland in 1967, giving lectures at various universities and hydrobiological laboratories. He chaired many national and international symposia and had organized first All-India Symposium on Inter-Tidal Ecology at Waltair.

He was connected with many scientific bodies and institutions. He was elected Fellow of the Indian Academy of Sciences (1953); Zoological Society of India (1954) and the Indian National Science Academy (1961). He served as a Member of Indian National Committee of Oceanographic research (CSIR), Advisory Committee, Indian Ocean Biological Centre (CSIR), Achievement Audit Committee, Central Fisheries (ICAR), Advisory Committee, Zoological Society of India and Scientific Panel for Fisheries Research (ICAR). He was also the Secretary-General and later President of the Zoological Society of India. Besides he served as a member of the Panel of Scientists, University Grants Commission and Member of the Editorial Boards of several scientific journals.

PERSONAL VIRTUES

Professor Ganapati was a teacher *par excellence*. His teaching was marked by detailed treatment of the topic. He never confined himself to the prescribed portion alone but covered additional grounds throwing light on the teacher's original study of the topic.

Inspite of his high stature and busy schedule, he was always available to the students and his colleagues for academic discussions. He was soft spoken and dignified, but when necessary very outspoken also. He was a modest and warm individual with a score of students, friends and admirers all over the world.

FAMILY

He was married on May 21, 1939 at Alwaye to Srimati Sita, the eldest daughter of his maternal uncle. He had two sons and two daughters. The eldest son took his PhD in Pharmacy in USA where he is currently teaching. The second son passed B Tech from Andhra University and is currently working at Visakhapatnam. The elder daughter is an MSc in Zoology and is married to Dr K A Balasubramanyam who is currently the Professor and Head of the Department of Plant Pathology at the A P Agricultural University, Hyderabad. The Younger daughter is a Medical Doctor and married to a senior customers engineer in the IBM, Madras.

DEATH

He died suddenly on January 5, 1984 at Bombay due to a massive heart attack within a few hours after his return from USA. In his death, the zoological community of India lost a great savant and the Andhra University a dedicated scientist. He will be remembered not only for his scholarship but also for his deep sense of humanism.

R NAGABHUSHANAM
R SAROJINI

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AJUDHYA NATH KHOSLA

(1892–1984)

Elected Fellow 1951

"An eminent engineer, an able administrator and a generous human being" will be the epithets by which AJUDHYA NATH KHOSLA will be known to the posterity in India. Belonging to a generation of Indians, born when the country was under foreign domination, Dr Khosla was proud to be an Indian and had great confidence in the capabilities of Indian engineers. There is no doubt that he had few equals to match his qualities, achievements and abilities.

EARLY LIFE AND EDUCATION

Ajudhya Nath Khosla was born in Jullunder City in the Punjab on December 11, 1892. He had his early education at the Government High School and later at the Anglo-Sanskrit High School, Jullunder, from which he passed his Matric examination in 1908. He had his college education at the DAV College, Lahore, from where he graduated in Arts (Hons) in 1912 securing the first position in the University and the highest marks in mathematics. Young Khosla joined the Thomson College of Civil Engineering, Roorkee in October 1913 and graduated with honours.

SERVICE AND RESEARCH CAREER

Soon after passing out from the Engineering College, in July 1916, he joined the Punjab Public Works Department (Irrigation Branch). It is interesting to note that his first assignment was to investigate and survey connected with Bhakra Dam Project, a major challenge faced and overcame by him with great distinction in later life. The dam, one of the highest in the world, stands on the same axis as he had proposed in 1917 as an apprentice engineer.

From July 1918 to March 1920, during the First World War, he was with the Mesopotamia Expeditionary Force in Iraq as a Commissioned Officer, when he made his first original contribution to engineering by designing Khosla Disc for precision levelling across rivers and wide valleys.

He was appointed to the Indian Service of Engineers in 1919 and returned to India in 1920. He was posted to the Sutlej Valley Project first on the surveys and investigations of all the four headworks and was then posted to the Sulemanki headworks for construction of the barrage. Here during 1921-26 he introduced precast concrete units for use on the barrage and precast reinforced concrete troughs for use on roofs and a variety of other structures. This type of construction saved the cost of formwork and expedited construction since the supports and the covering could be constructed and cured simultaneously. This cut down the time of construction considerably and proved economical in cost.

After completion of Sulemanki Head Works, Dr Khosla was posted successively, to the Headworks of the Upper Chenab Canal, to the Punjnad Barrage and to the Headworks of the Lower Chenab Canal at Khanki. The Weir there was reconstructed during his tenure as Executive Engineer. During these nine years he carried out intensive research on the flow of water through sub-soil in relation to stability of Hydraulic structures. This research culminated in 1936 in the publication of his paper on "Design of Weirs on Permeable Foundation"*. The method of design set out in this publication was adopted in the design of several weirs and barrages and other major hydraulic structures on permeable foundations undertaken in India and other countries and showed consistent success. The method was based on the solution of the well known Laplacian equation which governs the seepage of water through homogenous pervious media. This equation was not integrable for the complex boundary conditions of weir and barrage foundations. The 'method of independent variables' devised by Dr Khosla was remarkable for its ingenuity. He broke up the complex profile into a number of simple integrable profiles, and then superposed them. It was proved by electrical analogy experiments that the results so obtained, and subject to certain corrections given by Dr Khosla, were well, within the desired accuracy. This is his most outstanding contribution to engineering science. Only recently, with the development of speedier numerical methods and availability of fast computers, the use of his paper has been supplemented by new techniques.

This research work, was carried out in addition to the executive duties of the appointments held by him, was a major contribution to engineering science, to the theory and technique of design of river works, and of major hydraulic structures.

In 1926-27, trouble at the syphons under the Upper Chenab Canal became acute. These siphons are for large natural drainages in the head reach of the canal (capacity 12,000 cusecs), completed and opened in 1912, and must have been giving constant trouble ever since. Cracks appeared at the upstream and downstream ends due to undermining of the sub-soil. Repairs were carried out on the accepted Bligh theory but the trouble persisted. As officer-in-charge of the syphons, Dr Khosla initiated steps to probe into the real cause of the chronic problem. A set of pressure pipes with well-points were inserted in the floors of two of these syphons and the observations disclosed that the pressures indicated by these pipes had absolutely no relationship with those calculated from the Bligh Theory."

In 1930. Dr Khosla presented to the Punjab Engineering Congress two papers embodying the results of his researches. Briefly, the simple creep theory of Bligh was repudiated and some provisional and important conclusions were arrived at, notable among which were :

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*Khosla A N, Bose, N K & Meckenzie Taylor, E 1936. Design of Weirs on Permeable Foundations. CBIP Publication No. 12.

(a) The outer faces of the end sheet piles were much more effective than the inner ones and the horizontal length of floor,

(b) The intermediate piles of smaller in length than the outer ones were ineffective except for local redistribution of pressures,

(c) Undermining of floors started from the tail end. If the hydraulic gradient at exit was more than the critical gradient for the particular sub-soil, the soil particles would move with the flow of water thus causing progressive degradation of the sub-soil, resulting in cavities and ultimate failure,

(d) It was absolutely essential to have a reasonably deep vertical cut-off at the downstream end to prevent undermining,

(e) There was an urgent necessity for research work with regard to pressures under existing and new structures and in the laboratory. The former could be done by inserting suitably located pressure pipes in these structures and by maintaining a continuous and comprehensive record of the observations of pressures from those pipes.†

Following the failure of the new Islam barrage in September 1929, two years after it had been built, it was decided to extend the Panjnad barrage, which had, by then, been almost completed as per earlier design. This afforded the opportunity of putting in a comprehensive set of pressure pipes and of conducting full scale experiments. His Executive Engineer complained of the weir being turned into a sieve by the holes to be made for the pressure pipes. The pipes were, however, installed as per Dr Khosla's recommendations. He was, in due course, transferred to Panjnad when the Barrage there was opened. Dr Khosla was thus enabled to supervise the observations of pressure under the floor of the new barrage. This was the first full size experiment in the world, and the results obtained from it paved the way to the final solution of the problem. The main conclusions were :

(a) The flow of water through the sub-soil is in stream lines and therefore susceptible of mathematical treatment.

(b) The ratio of uplift pressure at any point along the base of a particular weir founded on permeable soil to the total head is constant and independent of the head, the class of sub-soil (so long, as it is homogenous) and temperature, but it varies with silt deposits or scour upstream or downstream of the impervious floor.

His next prominent achievement was the construction of the Trimmu Barrage, which was designed according to the method developed by him. He completed this work in a record time of two years. Similar barrages of this magnitude used to take about 5 years to complete. This was the first major project ever entrusted to an Indian engineer. Its completion in record time and at a substantially lower cost was a tremendous gain for the prestige of Indian engineers. This was also one of the most important applications of the precast concrete units.

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†Khosla A N 1935. Observations and Record of Pressures below Works on Permeable Foundations. CBIP Publication No. 8.

As Superintending Engineer, High Dam Circle, from 1941 to 1943, he investigated the water and power resources of the Punjab and prepared plans for their development, a number of which have been or are being implemented. During this period, he made an important contribution by establishing a rational relationship between "Rainfall and Runoff" and wrote his paper on "Silting of Reservoirs".** His approach to the runoff problem was also characterised by simplicity. Assuming that all precipitation which does not evaporate must contribute to runoff, and further that evaporation could be taken as a function of temperature alone, he correlated the runoff to mean temperature.

The figures given by him for rate of silting of reservoirs was the first quantitative estimate for India and was of great help to planners. The actual silt measurements on reservoirs completed during fifties and sixties have shown considerably higher rates of silting—presumably due to accelerating rates of removal of vegetal cover.

Dr Khosla brought about an agreement in 1943 with the Punjab Government and Raja of Bilaspur (now in Himachal Pradesh) about submergence of part of his territory in the proposed Bhakra reservoir. This cleared the way for the construction of Bhakra Dam which had been held up since 1943.

In 1944, Dr Khosla was elected Chairman of the Indian Science Congress, Engineering Section. In February 1945. Dr Khosla was appointed to the post of Consulting Engineer to the Government of India for Waterways, Irrigation and Navigation. In April of that year, on the creation of Central Waterways and Irrigation Commission (later Central Water and Power Commission and now Central Water Commission), Dr Khosla was appointed its Chairman. He continued to hold the post of Consulting Engineer also. Later he was made ex-officio Additional Secretary to the Government of India. He organised this Commission from scratch and simultaneously re-organised and developed the Pune Research Station at Khadakvasla into the Central Water and Power Research Station. These years, till his retirement from the post in 1953, marked a period of outstanding achievements in the field of river valley development.

He initiated investigations on the water and power potential of river valleys in the country as a whole and of several individual projects. Many of these like the Bhakra, Chambal, Damodar Valley, Hirakud, and Tapti (Ukai and Kakrapara) projects have been completed, and others on the Narmada' and other rivers are under construction or under active consideration. Special mention should be made of the Hirakud project on the Mahanadi river, which he conceived in May 1945 soon after assuming charge as Chairman, Central Waterways, Irrigation and Navigation

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**Khosla A N 1953. Silting of Reservoirs, CBIP Publication No. 51.

Commission, as the first stage of his plan for the integrated development of the Mahanadi valley. He directed its construction till 1953. This project was completed in early 1957—a record time of 12 years between conception and completion of a project of this magnitude. Dr Khosla also initiated investigations for a Dam on the Kosi at Barakashetra near the Indo-Nepal Border. This project is yet to materialise.

At the time of partition in 1947, many engineers opted for service in India, while the eastern part of Punjab could not absorb all of them. A major decision was then taken that the construction of Bhakra Dam and other projects be undertaken by Punjab directly through their own engineers and not through contractors. This would also train Indian engineers in planning and construction of major projects on their own. This idea proved to be highly successful.

His other achievements during this period were the settlement of differences between Madras and Orissa States on the Machkund project and between Hyderabad, Madras and Mysore States on the Tungabhadara projects.

In 1953-54 as Special Secretary to the Government of India, he led the Indian delegation to the United States for the Indus Waters dispute with Pakistan. These negotiations, in which he played a crucial role led to the World Bank proposals, which later formed the basis of the Indus Water Treaty between India and Pakistan. According to this treaty, Sutlej, Beas and Ravi rivers could be utilised fully by India, and the western rivers—Chenab, Jhelum and Indus could also be utilised by India for Run-of-the River Power Schemes. This decision when fully implemented through construction of projects on these rivers will make Punjab, Haryana and Rajasthan the granaries of India. It may be hoped that, some day a large part of Rajasthan will cease to be a desert.

On September 17, 1954, he assumed charge as Vice-Chancellor of the University of Roorkee, his *alma mater*, a post which he held for a little over five years. During these formative years of the university there was a great expansion not only in its size but also in the quality of its activities. His contributions as Vice-Chancellor included the establishment of the Water Resources Development Training Centre, Refresher Courses Department for serving engineers and teachers, and the School of Research and Training in Earthquake Engineering—which are even today prestigious and distinctive Departments of this University. During this period admissions increased four-fold. New laboratories and other buildings were built. Post-graduate courses and research work were expanded considerably.

One instance of his level of thinking may be mentioned here. A scheme was prepared for the establishment of a School of Research in Earthquake Engineering. This estimate amounted to Rs 15 lakhs for the first five years. When the scheme was put up to Dr Khosla, he asked "Do you require only 15 lakhs?" It was explained to him that since CSIR did not permit allocation of foreign exchange, equipment would have to be designed and fabricated at the School. This would naturally be a slow process and that was why it would not be possible to utilise more than that amount effectively. He was very appreciative of the idea of taking up design of equipment locally since it meant "import substitution" and would generate confidence among the scientists engaged in that work. Others thought that the sum of Rs. 15 lakhs was very ambitious since for midfifties, it was quite a large sum for a University; but not for Dr Khosla. He always thought of things in a big way. Incidentally, scientists engaged on this work are now internationally known for their work and are tackling the most intricate problems of Earthquake Resistant Design of major structures in the country.

Another point worth mentioning here is that once this scheme was submitted to him for processing it with the CSIR, he took over the responsibility of getting it sanctioned, and told the scientists concerned that they should concentrate their attention on the preparation to establish the school. Such an attitude encourages the young scientists enormously since they have a leader who takes full charge of the administrative problems. He was, therefore, a leader among men who inspired the younger generation to achieve higher goals without being bogged down by bureaucratic hindrances. He was also a person who considered "rules and regulations" as "guides" and not "masters", and that was why he succeeded in contributing so effectively in every field of his activity.

Out of the savings of Dr Khosla's consulting fees amounting to Rs 1,15,000, supplemented by contributions from the earnings of other staff for similar work, a fund has been created at the University to award prizes for good research work. The prizes carry his name and are greatly valued by those who earn them. In 1957, he was deputed by the Government of India to advise the Government of Sudan on the appraisal and development of water resources in that country.

He was a Member of the Rajya Sabha from April 1958 to October 1959. In December 1959 he was appointed Member of the Planning Commission in-charge of Education, Health and Scientific Research. In 1962, he was appointed Governor of Orissa. This marked the first time an engineer was appointed as Governor of a State. Despite his exacting duties as Governor, Dr Khosla continued to take active interest in professional activities, particularly in river valley development. He retired from the post of Governor in January 1968.

He continued to be the Chairman of the Board of Consultants of various river valley projects like Balimela, Beas, Bhakra, Pamba-Kakki (Sabargiri), Ramganga and Yamuna.

Dr Khosla was appointed by the Government of India as Chairman of the Committee for preparing a Master Plan for the optimum and integrated development of Narmada water resources—a plan which he had originally mooted in outline in 1945-46.

After his retirement as Governor of Orissa, he devoted most of his time to the education and socio-economic uplift of the tribals, harijans and other weaker sections in the State of Orissa. Dr Khosla established a Women's Degree College, a Women's Polytechnic and a Girls' High School at Rourkela, and three colleges and four High Schools for boys, a Teachers' Training School, an Auxiliary Nursing and Midwifery

Training Centre, and three Medical Aid Centres at various places in Orissa. Also, he established a residential High School for Adivasis at Lungei (near Rourkela). All these educational institutions were under the management of DAV College Trust and Managing Committee of which Dr Khosla was Vice-Chairman. They are located in the backward area of Orissa and their establishment needed a large sum of money. His wife Smt Susheela Khosla contributed the first one lakh of rupees from her personal savings to start this scheme.

AWARDS AND HONOURS

Dr Khosla was awarded a number of Gold Medals for his outstanding performances. Some of these are : William Rattigan Medal for standing First in BA Examination in 1912; Rai Bahadur Kanaihya Lal Medal for Civil Engineering from Civil Engineering College, Roorkee; two medals from Punjab Engineering Congress in 1930 and 1936 respectively; Kennedy Medal from Punjab Irrigation Department in 1940; Medal from National Institute of Sciences in 1960 and the Shanti Swarup Bhatnagar Medal from Indian National Science Academy in 1974.

Dr Khosla was elected to numerous high offices in national and international bodies and conferences. From a list too numerous to be catalogued should be mentioned the following : President of the Institution of Engineers (India), 1949-51; President of the Central Board of Irrigation and Power, 1946-48 and 1951; President, National Institute of Sciences of India (now Indian National Science Academy) 1960-62; Founder President, International Commission on Irrigation and Drainage, 1951-54, and its Honorary President; Vice-President, International Commission on Large Dams, 1946-51; Vice President, International Association for Hydraulic Research, 1948-53 and Vice-President, Union of International Engineering Organisations of the UNESCO, 1950-53. Dr Khosla was a Life Member of the American Society of Civil Engineers, and Honorary Life Fellow of the Institution of Enginees (India) since 1972.

He was the recipient of numerous honours. Before independence of India, he was awarded the title of Rai Sahib in 1929, and Rai Bahadur in 1933. After independence, the honour of Padam Bhushan was conferred upon him in 1955 and Padam Vibhushan in 1977 by the President of India.

Dr Khosla was awarded Doctor of Engineering (Honorary) by Renesselaer Polytechnic Institute, USA in 1956; Doctor of Engineering (Honoris Causa), University of Roorkee in 1959; and Doctor of Science (Engineering) (Honoris Causa), University of Punjab in 1961. He was awarded Doctor of Science (Honoris Causa) by Sambalpur University, Orissa, Indian Institute of Technology, Delhi, Orissa University of Agriculture and Technology, and by Jadavpur University.

PERSONAL QUALITIES

Khosla came from a modest middle class family. In fact, his father had to incur debt to bring up and educate his children. Dr Khosla paid these debts after joining service. Thus, he was not an inheritor of privilege and position; but rose to eminence by sheer merit, dedicated hard work, and pride in his profession. He never considered any work too small or too big for him. He was a person who became an example to many in his life time.

Dr Khosla was an eminent engineer—dynamic, determined and practical dreamer, planner of great vision, humane to the core, a philanthropist, friend of the under-privileged, believer in human dignity. He was an administrator par excellence. He was an inspiration to all who came in contact with him. His remarks in one of his speeches are worth quoting : "*In all scientific and technological advance, there is no substitute for thinking for one's self, for the habit of enquiry, for the drive for innovation, and for the gamble of experimentation". Accordingly—There can be no two opinions that an Engineer must remain a student all his life."*

He passed away on May 29, 1984, full of years, every one of which was an year of achievement, full of honours, and fully deserved.

JAI KRISHNA